NAVAL POSTGRADUATE SCHOOL
Monterey, California

THESIS

A COST-BENEFIT ANALYSIS OF THE REQUIREMENT THAT STUDENTS COMPLETE A THESIS AT THE NAVAL POSTGRADUATE SCHOOL

by

Michael R. Strobl

March 2001

Thesis Advisor: Stephen Mehay
Associate Advisor: Julie Filizetti

Approved for public release; distribution is unlimited.

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. AGENCY USE ONLY *(Leave blank)*	2. REPORT DATE March 2001	3. REPORT TYPE AND DATES COVERED Master's Thesis

4. TITLE AND SUBTITLE A COST-BENEFIT ANALYSIS OF THE REQUIREMENT THAT STUDENTS COMPLETE A THESIS AT THE NAVAL POSTGRADUATE SCHOOL

5. FUNDING NUMBERS

6. AUTHOR(S) Strobl, Michael R.

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
Naval Postgraduate School
Monterey, CA 93943-5000

8. PERFORMING ORGANIZATION REPORT NUMBER

9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES)
None

10.SPONSORING/MONITORING AGENCY REPORT NUMBER

11. SUPPLEMENTARY NOTES
The views expressed in this thesis are those of the author and do not reflect the official policy or position of the Department of Defense or the U.S. Government.

12a. DISTRIBUTION / AVAILABILITY STATEMENT
Approved for public release; distribution is unlimited.

12b. DISTRIBUTION CODE

13. ABSTRACT This thesis identifies and compares the benefits and costs of the policy requiring master's degree candidates at NPS to complete a thesis. It uses fiscal year 2000 data. The goal is to evaluate the existing policy to determine if the economic benefit of requiring a thesis is greater than the economic cost. The direct benefit of the thesis requirement is the increased productivity of officers due to having completed a thesis. Indirect benefits are found in the valuable research provided by many theses to the DoD. The most prominent cost of the thesis requirement is the opportunity cost of the student's time necessary to stay at NPS, and therefore out of the Fleet, in order to write a thesis.

This thesis estimates that the costs of the thesis requirement were approximately $19.8 million in FY2000. The indirect benefits of research completed by thesis students were between $8.3 million and $18.4 million. The direct benefits, in terms of its educational value, could not be quantified. Therefore, this report recommends that, until the direct benefits can be accurately quantified and monetized, the current requirement for thesis work remain as a condition for graduation from NPS.

14. SUBJECT TERMS Training and Education, Manpower Policy, Cost-Benefit Analysis			15. NUMBER OF PAGES 103 16. PRICE CODE
17. SECURITY CLASSIFICATION OF REPORT Unclassified	1. SECURITY CLASSIFICATION OF THIS PAGE Unclassified	19. SECURITY CLASSIFICATION OF ABSTRACT Unclassified	20. LIMITATION OF ABSTRACT UL

THIS PAGE INTENTIONALLY LEFT BLANK

Approved for public release; distribution is unlimited.

A COST-BENEFIT ANALYSIS OF THE REQUIREMENT THAT STUDENTS COMPLETE A THESIS AT THE NAVAL POSTGRADUATE SCHOOL

Michael R. Strobl
Major, United States Marine Corps
B.B.A., Mesa State College, 1987
M.B.A., Averett College, 1995

Submitted in partial fulfillment of the
requirements for the degree of

MASTER OF SCIENCE IN MANAGEMENT

From the

NAVAL POSTGRADUATE SCHOOL
March 2001

Author: _____
Michael R. Strobl

Approved by: _____
Stephen Mehay, Thesis Advisor

_____
Julie Filizetti, Associate Advisor

_____ for
Reuben T. Harris, Chair
Graduate School of Business and Public Policy

THIS PAGE INTENTIONALLY LEFT BLANK

ABSTRACT

This thesis identifies and compares the benefits and costs of the policy requiring master's degree candidates at NPS to complete a thesis. It uses fiscal year 2000 data. The goal is to evaluate the existing policy to determine if the economic benefit of requiring a thesis is greater than the economic cost.

The direct benefit of the thesis requirement is the increased productivity of officers due to having completed a thesis. Indirect benefits are found in the valuable research provided by many theses to the DoD. The most prominent cost of the thesis requirement is the opportunity cost of the student's time necessary to stay at NPS, and therefore out of the Fleet, in order to write a thesis.

This thesis estimates that the costs of the thesis requirement were approximately $19.8 million in FY2000. The indirect benefits of research completed by thesis students were between $8.3 million and $18.4 million. The direct benefits, in terms of its educational value, could not be quantified. Therefore, this report recommends that, until the direct benefits can be accurately quantified and monetized, the current requirement for thesis work remain as a condition for graduation from NPS.

THIS PAGE INTENTIONALLY LEFT BLANK

TABLE OF CONTENTS

TABLE OF FIGURES

THIS PAGE INTENTIONALLY LEFT BLANK

LIST OF TABLES

THIS PAGE INTENTIONALLY LEFT BLANK

ACKNOWLEDEMENTS

This thesis was made easier, if not altogether possible, due to the efforts of many people. In particular, I thank Ms. Danielle Kuska and Ms. Elaine Christian in the NPS Research Office, Ms. Layne Williams at the NPS Dudley Knox Library, Ms. Laura Zander in the NPS SPEAR office, Ms. Judy Joyce in the NPS Office of Instruction, Ms. Lisa Quidileg in the NPS Registrar's Office, and Dr. Janice Laurence at BUPERS. Their responses to my many, and often unfocused, requests for data were always cheerful, timely, and professional. They are a credit to NPS and the Navy.

This cost-benefit analysis was made more benefit than cost thanks to Dr. Stephen Mehay and Professor Julie Filizetti. Their insight and hard work were invaluable.

Finally, some who read this thesis may question the reality or magnitude of the opportunity cost a student incurs while writing a thesis. The cost is real. Stacey, Olivia, and Nathaniel Strobl paid the cost without complaint--and I thank them.

THIS PAGE INTENTIONALLY LEFT BLANK

I. INTRODUCTION

A. BACKGROUND

The Naval Postgraduate School (NPS) is the primary source of graduate education for the U.S. Navy and Marine Corps. Its mission is to enhance the combat effectiveness of the Navy and Marine Corps through education and research. As a means to accomplish this mission, most NPS degree programs require that all students complete a thesis as a condition for graduation. While this policy returns many economic benefits to the DoD, it also generates many economic costs. This thesis will identify, quantify, and compare those benefits and costs.

The thesis process hones the student's ability to identify a problem, gather relevant data, conduct critical analysis, and prepare a formal written report detailing the effort. Although difficult to quantify, there is certainly a benefit to be gained from this process. Indeed, this pedagogical value is the primary purpose for the thesis requirement at NPS. The thesis is considered an academic "capstone" experience that utilizes the knowledge and skills learned in prior coursework.

The Naval Postgraduate School is "an academic institution whose emphasis is on study and research programs that are relevant to the Navy's interests, as well as the interests of other arms of the Department of Defense (DoD)." [Ref. 19: p. 7] A large number of theses focus on practical problems within the Department of Defense. Many theses have offered innovative solutions to enhance warfighting capabilities or efficiencies. Others have resulted in significant cost savings for the DoD. Much of this

research, had it not been done by NPS students, would have been contracted out to dedicated research organizations such as the Center for Naval Analyses or the Rand Corporation or to private consultants. Contracted research projects can be very expensive and the costs avoided can be considered one of the benefits of the thesis requirement.

The thesis requirement at the Naval Postgraduate School also generates costs for the Department of Defense. The most prominent cost of the thesis requirement can readily be identified as the opportunity cost of the student's time necessary to stay at NPS, and therefore out of the Fleet, in order to write a thesis. The thesis requirement also creates a need for thesis advising. Without the requirement to advise thesis students, faculty members might be expected to increase productivity in other professional endeavors, particularly teaching or research. It is even possible that NPS might require fewer faculty members if there were no longer a need to advise thesis students.

In addition to these opportunity costs, the thesis requirement generates direct expenses associated with activities such as printing, processing, cataloging, and storing. These expenses, or variable costs, would be eliminated immediately if the thesis requirement were no longer in place.

Finally, it is significant to note that the accrediting bodies for NPS do not explicitly require a thesis in order to meet accreditation standards. In addition, as will be discussed below, most of the nation's top civilian universities offering master's degrees do not require a thesis. Thus, there is not universal agreement in the academic community as to the value of thesis work over other integrating experiences. Since NPS's accrediting bodies do not require that students complete a thesis to receive a

master's degree, we can consider the requirement to be a *policy choice* by the DoD and Navy. A goal of cost-benefit analysis, and of this thesis, is to measure and evaluate the allocative efficiency of such policy choices.

B. OBJECTIVE

The purpose of this research is to identify, quantify, and compare the benefits and costs of the Department of Defense's policy of requiring that master's degree candidates at NPS complete a thesis. The goal is to evaluate the existing policy to determine if the economic benefit (in terms of educational value and relevant research) of requiring a thesis is greater than the cost (in terms of opportunity cost of the students' and thesis advisors' time as well as the direct costs of thesis production).

C. RESEARCH QUESTIONS

Several questions arise when attempting to conduct a cost-benefit analysis of the thesis requirement at NPS. In order to monetize the value of research conducted by students, we must first estimate how many student theses are useful and relevant to the DoD. Once this has been determined, the issue of benefits can be addressed. What are the benefits to the Department of Defense of having students conduct relevant theses? What is the monetary value of the thesis research performed? What are the intangible or immeasurable benefits of the thesis requirement?

There are also many questions to ask when considering the cost of the thesis requirement. How much time does the current thesis requirement add to a student's tour at the Naval Postgraduate School? What is the opportunity cost of that additional time

spent working on a thesis as opposed to filling billets in the Fleet or supporting commands? What is the opportunity cost of the faculty involved in thesis advising and processing? What other costs are associated with thesis production?

D. SCOPE AND LIMITATIONS

This thesis will compare the benefits and costs of the current requirement for students to complete a thesis at NPS. The tangible benefits and costs of the thesis requirement will be identified and quantified where possible. The intangible benefits and costs will be identified and discussed. Sensitivity analysis will be used where appropriate to examine benefits and costs under varying assumptions. In order to uniformly compare monetized values, this thesis will compute all benefits and costs on an annualized basis.

Finally, this thesis is based on the assumption that the DoD can either maintain the current thesis policy or eliminate the requirement completely. In other words, this report is intended to isolate and illustrate the benefits and costs of two extremes of the thesis policy decision. It will not identify and evaluate other curriculum alternatives, such as eliminating the thesis but increasing classroom hours, implementing a comprehensive exam, or making all theses joint efforts but reducing time allotted. These options would need to be fully evaluated before a policy change could be made. In addition, this research will not examine the utilization rates of NPS graduates in billets requiring graduate education. It will not examine the reported or measured impact of the thesis experience on individual officers or defense organizations.

E. ORGANIZATION

This thesis continues in Chapter 2 with a look at theories pertaining to graduate education, including the value of a thesis at the master's degree level. Chapter 2 will include a look at current thesis requirements at some of the nation's premier graduate programs. It will conclude with a discussion of human capital theory.

Chapters 3 and 4 are dedicated to identifying and quantifying benefit and cost data, respectively. In each case, there will be a discussion of tangible and intangible benefits and costs. Chapter 5 includes sensitivity analysis of various assumptions. Chapter 6 will include a conclusion, recommendations, and suggestions for areas of further research.

THIS PAGE INTENTIONALLY LEFT BLANK

II. BACKGROUND AND THEORY

A. INTRODUCTION

This chapter will examine two relevant issues concerning the requirement for a thesis in a master's degree program. First, there will be a discussion of the value and quality of thesis work and its place in a master's degree program. This will include a look at accreditation standards applicable to NPS as well as the policies of some of the nation's top universities with regard to thesis requirements.

Following that will be a discussion of human capital theory. This section will attempt to identify the theoretical framework relevant to an assessment of the opportunity costs of students attending NPS and completing a thesis--primarily from the Defense Department's viewpoint.

B. THE VALUE OF A THESIS

The thesis is required at the Naval Postgraduate School because it is regarded as an integral part of the master's degree program. As such, it is a requirement for completion of a master's degree as specified in the NPS Academic Council Policy Manual. Additionally, the *Naval Postgraduate School General Catalog* lists Educational Skill Requirements (ESR) for each curriculum at NPS. These ESRs define the fundamental concepts required in the graduate education curriculum as directed by each curriculum sponsor. [Ref. 19: p. 26] To use Shore Installation Management (curriculum 877) as an example, the final ESR, on a list of 11, reads as follows:

11. ANALYSIS, PROBLEM SOLVING AND CRITICAL THINKING: The graduate will demonstrate the ability to conduct independent research and analysis, and proficiency in presenting the results in writing and by means of a thesis appropriate for this curriculum. [Ref. 19: p. 187]

This ESR appears in some form in every curricula at NPS.

These ESRs are evaluated every two years by the curriculum sponsor, generally a flag or general officer, with the intent of determining if they still describe the skills required of the graduates of the program. The value and need for a thesis as part of the program is generally reviewed and affirmed at these reviews.

As will be discussed below, there are many cogent arguments for the inclusion of a thesis requirement in graduate education. There are also, however, enough considerations to the contrary to make the value of a thesis not necessarily self-evident. The remainder of this section will examine various schools of thought concerning the value of a thesis.

1. What the Literature Says

The requirement for acquiring research skills has long been considered one of the qualities differentiating undergraduate and graduate degrees. Speaking on the difference between undergraduate and graduate education, Professor Henry G. Booker of the Department of Electrical Engineering at Cornell University said:

> Graduation [from undergraduate education] should signify that a student's mind is about as developed as it can be merely by studying what is well known. By contrast, it should be the object of graduate education to develop the student's mind by having him think through things that have not been completely thought through so far as the student is aware. Research should thus be the principal tool of graduate education. [Ref. 13: p. 88]

Most graduate education programs, including NPS, either explicitly or implicitly seek to cultivate students' critical thinking skills. Indeed, this goal of enhancing critical thinking skills is one of the basic tenets of Socratic education. Among the essential elements of critical thinking are a "disposition for disciplined inquiry, based on a readiness to question all assumptions and an ability to recognize when it is necessary so to question." [Ref. 9: p. 52]

If we accept that the development of critical thinking skills is one of the goals of graduate education, we must turn our attention to the question of just how to evaluate critical thinking. The following passage is representative of the prevailing school of thought concerning evaluation of critical thinking skills.

> Most research seeking attributes of critical thinking in university students is based on analysis of written work as evidence of modes of thinking. In many cases, tests have been used, but these have often focused on very elementary reasoning skills. Research on what critical thinkers produce must begin now to analyze more complex writing. [Ref. 9: p. 58]

In other words, demonstration of critical thinking skills can be accomplished, at least in part, by producing a detailed essay resulting from original (at least to the student) research. Further, the "capacity to produce an adequate academic essay on the basis of an original individual inquiry and research effort is an essential characteristic of a finished and professionally competent scholar." [Ref 13: p. 56]

A properly administered thesis project will also require the student to call on a number of complex abilities.

> The activities involved in producing a document that presents a student's research or practicum results were important because they encouraged students to integrate perspectives developed both in core course work and in doing-centered learning experiences and to use and further develop their

> analytical and written communication skills. Further, since the completion of a tangible product required a significant amount of time, individual effort, and mental endurance, students often became more self-confident in their abilities to make valuable contributions to their field. [Ref 7: p. 302]

Students must have a command of basic skills as well as be comfortable with more sophisticated concepts of the particular discipline in order to carry out meaningful research.

> The thesis requires the student to integrate and apply several academic course skills to an open-ended, unstructured problem. This experience is very important in the education process at NPS since much of the class work is quite structured and since most of the graduates will not become actual practitioners of the fields in which they are being educated. [Ref. 20: p. 26]

In this way, the thesis acts as the culmination of the graduate education experience.

While acknowledging the educational value of a master's thesis, it is also important to recognize some limitations. The following points are particularly relevant prior to any attempt to quantify the benefits gained from thesis work at NPS.

Comparing the thesis to a doctoral dissertation is one way to highlight the limited purpose of the master's thesis.

> It is only at the doctorate level that there is justification for the requirement that a thesis shall comprise an original contribution to knowledge as evidence of expertise acquired. In respect to the thesis for a master's degree, the time conventionally assigned is limited and the student is usually inexperienced in research. It should be clear, therefore, that the objectives of the master's thesis are not necessarily the same as those of the doctorate. A commonly accepted principle in the curriculum leading to a master's degree..., is that the master's thesis is to be primarily considered as a contribution to the training of the candidate rather than a contribution to knowledge. [Ref 22: p. 73]

This point must be remembered as we later attempt to quantify the benefits of the thesis requirement by the valuable research it provides to DoD. The purpose of a master's thesis is not necessarily to produce groundbreaking research. Rather, the purpose is to train the student. Such training should prepare the student to apply the research skills and knowledge acquired to real-world problems.

As mentioned above, one of the qualities expected of critical thinkers is the ability to recognize when it is necessary to question. This implies that the student is capable of choosing a proper research topic. "Unless one can exercise such choice he cannot place himself in position to write the necessary essay. Neither can he demonstrate intellectual maturity appropriate to the degree sought." [Ref. 13: p. 76]

Common practice at NPS, however, is that students are given thesis topics by either external agencies or NPS faculty—usually in conjunction with research being conducted by the faculty or in support of a problem identified by the agency. This custom attained the status of a codified policy when, in 1990, a committee chaired by the Dean of Academic Administration wrote that the "...ultimate responsibility for the [thesis] problem selection ...lies with the thesis supervisor." [Ref. 20: p. C-26]

Many thesis topics at NPS, including this one, did not demand that the student "recognize when it is necessary to question." The practice of advisors or professors assigning thesis topics to students has been called "typical of those who are poorly prepared for graduate work." [Ref. 13: p. 163] This limitation of thesis work, as commonly conducted at NPS, must be recognized before evaluating the benefits of student research for the DoD.

2. What is Current Common Practice

As stated above, the thesis is required at the Naval Postgraduate School because it is regarded as an integral part of the master's degree program. This view, however, is not universally shared among other graduate degree granting institutions. Many highly regarded master's degree programs throughout the nation do not require a thesis. In addition, none of the four accrediting bodies for NPS explicitly requires a thesis as a condition for awarding of master's degrees.* (While, the accrediting bodies do not explicitly require a thesis, they do, however, require a certain amount of research and/or integrative experiences that reflect the appropriate level of engagement in the field of study.)

In his 1998 thesis, John Lathroum compared the NPS Graduate School of Business and Public Policy (then known as the Department of Systems Management) with some of the nation's best graduate degree programs. Lathroum identified the following list of the top ten institutions offering master's degrees in Public Management. [Ref. 15: p. 56]

1. Harvard University, John F. Kennedy School of Government
2. Yale University, School of Management
3. Stanford University, Graduate School of Business
4. University of California, Berkeley, Haas School of Business

---

* The four accrediting bodies for NPS are the Accrediting Commission for Senior Colleges and Universities of the Western Association of Schools and Colleges, the Accrediting Board for Engineering and Technology, the National Association of Schools of Public Affairs and Administration, and the International Association for Management Education.

5. Carnegie Mellon University, H. John Heinz III School of Public Policy and Management
6. University of Maryland, School of Public Affairs
7. Syracuse University, The Maxwell School of Citizenship and Public Affairs
8. Willamette University, Atkinson Graduate School of Management
9. University of Southern California, School of Public Administration
10. George Washington University, School of Business and Public Management

These schools all have curricula in Public Management that are somewhat comparable to curricula found in NPS's Graduate School of Business and Public Policy. Of these top ten programs, however, only George Washington University offers a thesis (and even there it is optional). [Ref. 15: p. 125]

Lathroum found a similar pattern in the nation's top ten Master's of Business Administration (MBA) programs. While five of the top ten MBA programs required or offered business projects or internships, only one, the Massachusetts Institute of Technology (MIT), offered an optional thesis. [Ref. 15: p. 109]

In its 2000 annual rankings of the nation's top Aerospace/Aeronautical engineering graduate programs, *U.S. News and World Report* compiled the following list of top universities: [Ref. 23]

1. Massachusetts Institute of Technology
2. Stanford University
3. California Institute of Technology
4. University of Michigan
5. Georgia Institute of Technology

6. Purdue University
7. Princeton University
8. University of Illinois-Urbana-Champaign
9. University of Texas-Austin
10. Cornell University

Of these ten, only two, Massachusetts Institute of Technology and California Institute of Technology, required a thesis. Five of the top ten had an optional thesis track. It is presumed that these degree programs have some integrative product or report in order to ensure the quality of their programs, however, they do not require a thesis.

While the practices of some of the nation's premier universities are relevant to this study, comparisons of NPS with civilian universities must be done with some caution. The uniqueness of NPS needs to be recognized.

A key difference between NPS and civilian universities is the combination of general and job-specific education received at NPS. General education can be thought of as the acquisition of skills that are usable elsewhere (i.e., outside of the Navy). Job specific training is of use only to one's employer. Civilian universities impart general education. Much of the curricula at NPS can also be considered general education. For example, Calculus and Statistics are certainly not unique to the Navy.

However, in addition to general education, the Naval Postgraduate School seeks to provide curricula that are militarily relevant, meeting Navy and Marine Corps subspecialty and general education requirements. Many courses, therefore, are job specific and of little use outside the Navy. Further, NPS curricula are subject to biennial

Navy flag-level sponsor review for military relevancy, with the ability to implement desired course and program changes swiftly. [Ref. 18: p. 61] These differences between NPS and civilian universities demand recognition when comparing the programs.

C. HUMAN CAPITAL THEORY

Much of the literature on human capital theory focuses on the individual employee and the role he or she plays in investing in human capital, particularly in formal education. The focus of this study, however, is on the investment decision of the employer—the Department of Defense—and not the individual. This thesis is concerned with the costs and benefits of the thesis as they pertain to the DoD. Costs or benefits to the individual (i.e., the student) are regarded as incidental and will not be considered. This report assumes that the student has no "standing" (a term used in cost-benefit analyses) in the decision to include a thesis as a requirement for graduation. In this light, the Defense Department makes investments in the human capital stock of its employees.*

In the case of full-time graduate education of its officers, the DoD can be considered the investor. Economic theory assumes that firms (in this case DoD) invest in capital in order to enhance profits. This theory is based upon the rationale that future returns from investments justify the costs. Firms will continue to undertake investments as long as the net present value of investments is non-negative. [Ref. 2: p. 22]

---

* This is not to say that the DoD is not concerned with the benefits officers receive by attending NPS. Rather, it recognizes that, if the student's costs and benefits were to be included in this discussion, we must be allowed to acknowledge that the student has choices over his course of instruction, whether or not to attend NPS (in the very short run), or even whether or not to stay in the service. In the short run, the student does not have such choices. For purposes of this study, it is assumed that students are not attending NPS for the purpose of improving their personal capital. They are at NPS to benefit the DoD.

The Department of Defense's decision to invest in officer education can be modeled by the following formula:

$$NPV = [B_1/(1+r) + B_2/(1+r)^2 + \ldots B_k/(1+r)^k] - C_0,$$

where NPV is the net present value of the future stream of net benefits. In this case, the benefits are the difference in productivity between an NPS graduate and a non-graduate. The B_k represents the benefits realized due to the education over the relevant lifespan of the project (in the case of NPS education, the lifespan of the project is the time the officer spends on active duty after leaving NPS). The benefits must be discounted over the life of the project by an interest rate, r, in order to set the present value of benefits equal to the present value of the costs. The C_0 represents the costs incurred during the education. Costs in this case include the actual cost of delivering the education (schoolhouse costs) plus the opportunity cost of the officer's time. The DoD should invest in officer education only if the Net Present Value is positive.

For an individual officer, the difference between his productivity and salary can be considered his net benefit to the DoD. During the time an officer is attending NPS, the DoD incurs the full cost of his salary and benefits but loses the productivity of the officer in his operational specialty.

Over the course of an officer's career, one would expect that the DoD would realize an ever-increasing stream of net benefits as the officer gains knowledge and experience in his field. Figure 2.1 is a model of such a phenomenon. In theory, as time passes and the officer with graduate education gains knowledge and experience, his productivity rises. The lighter shaded line in Figure 2.1 represents the rising net

productivity of a hypothetical non-graduate degree-holding officer. Of course, the intercept and slope of the productivity line will vary for each officer. This particular figure is only intended to illustrate the theory involved.

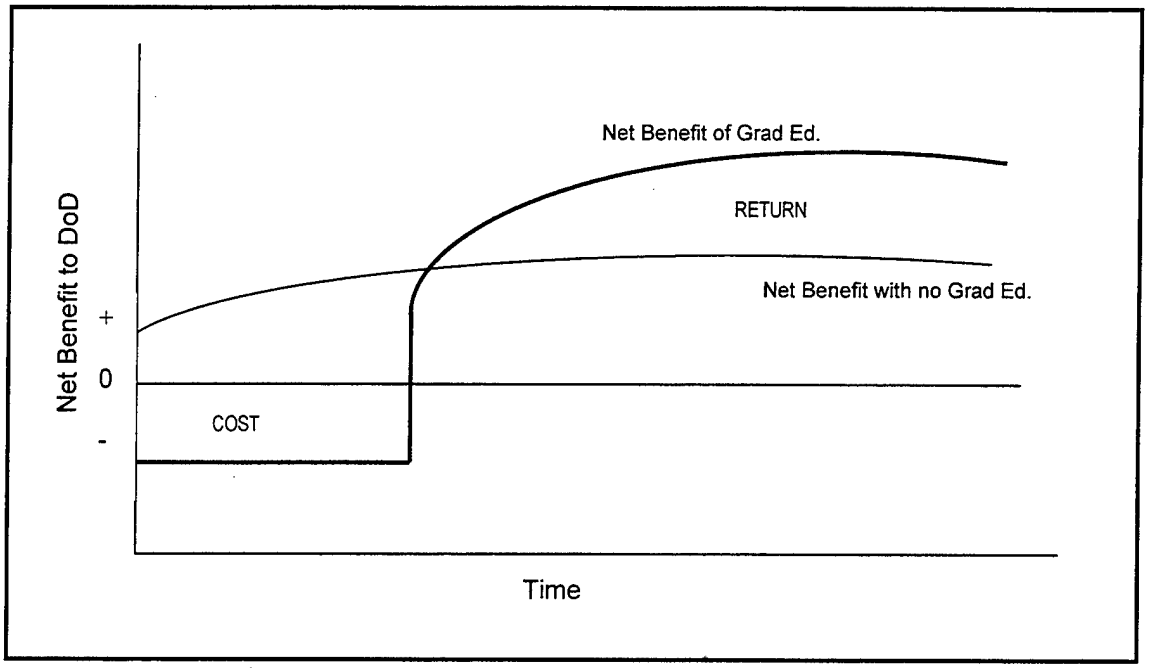

Figure 2.1. Alternative Productivity Streams
(Graduate Education vs. No Graduate Education)
Source: From Ref. 9

The heavier line represents the hypothetical net productivity of an officer who attends NPS. During the time at NPS, his net productivity is negative--he is receiving full pay and benefits but is not contributing to operational readiness. Once he leaves NPS, however, one would expect that, after a brief period of reorientation, his productivity would overtake that of the officer without graduate education. In fact, his productivity may actually increase over time relative to the officer without graduate education. (Again, the slope and intercept of these curves in Figure 2.1 are only intended to demonstrate the principle of human capital theory from the point of view of the DoD.

The specific slopes and intercepts of the productivity curves must be identified empirically.) As Figure 2.1 shows, "all forms of training are costly, in the sense that the productivity of learners is low, and all represent a conscious *choice* on the part of the employer to accept lower current productivity in exchange for higher output later." [Ref. 10: p. 306]

Significantly, Bowman and Mehay verify the proposition that an officer tends to increase his productivity in the Navy after completing graduate education. Their 1998 study examined the specific relationship between graduate education and on-the-job performance in the Navy. Using promotion rates as a proxy for on-the-job productivity, they found that the effects of graduate education were positive and statistically significant. [Ref. 3]

The fundamental assumption underlying Figure 2.1 is that the officer has negative net productivity to the DoD during the period of graduate education. During this time, the officer is receiving full pay and benefits but is not "producing" national defense. Once graduated, however, he or she can be expected to contribute more to the DoD than an officer without a graduate degree.

In Figure 2.2 below, we add another possible "career path." The new curve (dotted line) represents an officer who attends NPS but does not complete a thesis. The difference between point A and Point B represents the additional time devoted to thesis work. Thus, the student not required to complete a thesis leaves NPS sooner, presumably returning to an operational billet, and sees his or her net productivity go from negative to positive earlier than the student who is required to stay at NPS to complete a thesis.

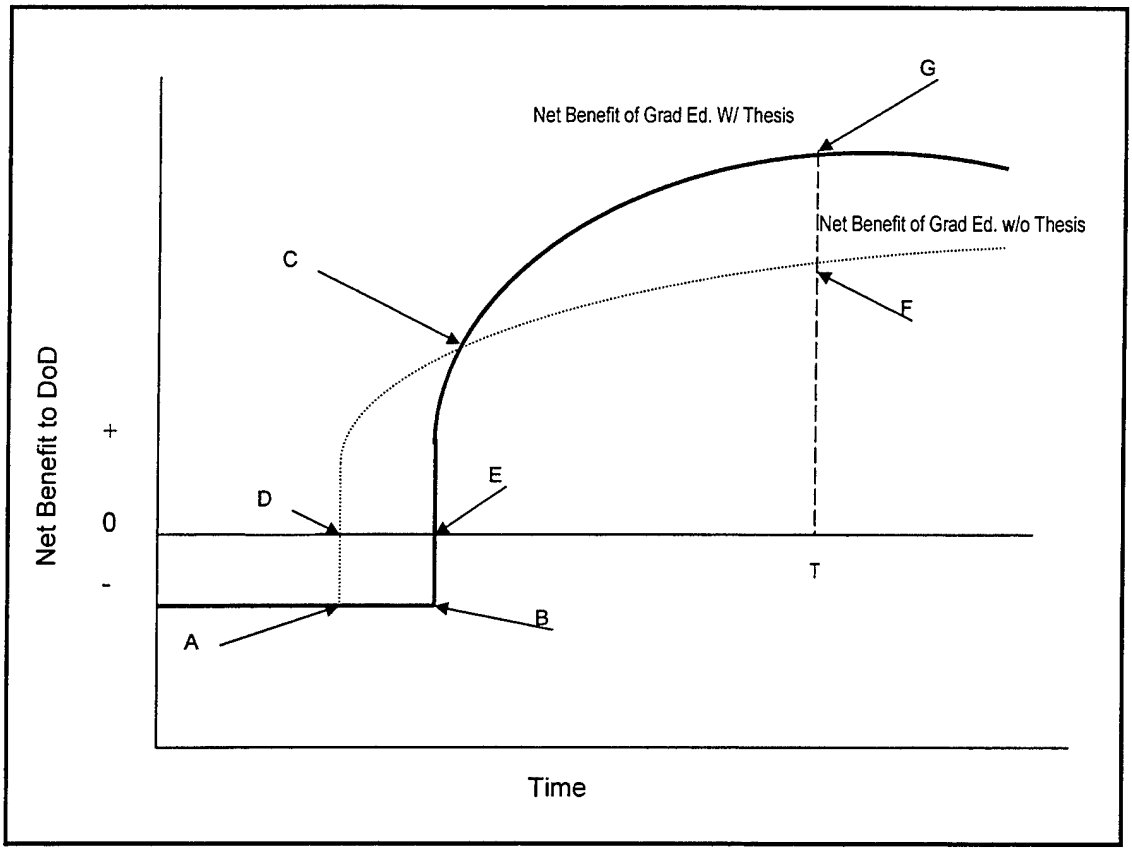

Figure 2.2. Alternative Productivity Streams
Grad Ed with Thesis vs. Grad Ed without Thesis
Source: Text

It is possible, however, that the officer who does complete a thesis is a more productive officer over the remainder of his or her career (why else would the DoD—the "investor"—require a thesis?). Figure 2.2 recognizes this possibility by showing Point C where the net productivity of the thesis writer overtakes the net productivity of the non-writer.

Thus, the area bounded by points A, B, and C represents a positive net benefit (costs avoided) accruing to the DoD if the student does not complete a thesis and returns to the Fleet. Area ABDE represents direct costs avoided by sending the student back to

the Fleet sooner, and area CDE represents the productivity advantage accruing to those who return to the Fleet sooner (opportunity costs avoided). The area beyond point C and between the "Grad Ed With Thesis" and "Grad Ed Without Thesis" lines (area CFG) represents increased productivity, and therefore, greater net benefit to the DoD of a student who completes a thesis. This productivity advantage is assumed to continue until the end of the officer's tenure in the service at time T. Point T, of course, will differ individual officers, and will affect the size of area CFG.

Although there is a clear reduction in cost if the thesis requirement is eliminated, the key question is what is the difference in net return to a degree with a thesis versus one without a thesis. In other words, for the average officer, is the net present value of the difference in productivity (i.e., the benefit of the thesis as represented by area CFG in Fig. 2.2), minus the net present value of the area bounded by points A, B, and C (the cost of the thesis) positive or negative?

D. CHAPTER SUMMARY

There are many valid reasons for a thesis requirement in a master's degree program. The thesis can serve as a capstone to a complete master's degree. It can be a tool to both sharpen and evaluate a student's critical thinking skills. It can be the vehicle for applying research skills and knowledge learned to a real world problem.

There are, however, some limitations to the thesis experience, especially as practiced at NPS. While many NPS theses provide valuable research to the DoD, much of the relevant literature claims that a thesis should be a vehicle to "train the candidate rather than contribute to knowledge." In addition, students at NPS are routinely

presented with thesis topics from various sources. However, as shown above, it has been argued that student selection of an appropriate topic is one of the requirements for a complete thesis experience.

Interestingly, many of the nation's top graduate schools do not require a thesis in master's degree work. In fact, the majority of the most prominent schools do not. Obviously, the value of a thesis is not accepted everywhere as self-evident.

Finally, this chapter looked at human capital theory with the perspective of the Defense Department as an "investor" in human capital. It was established that investments in officer education by the DoD incur a cost in the form of the opportunity cost of the officer/student's time. This investment is then expected to generate a benefit in the form of a more productive officer. This assumption was examined by conceptually comparing the net productivity of an NPS student with a non-student. The net productivity of the NPS graduate was then compared to a hypothetical net productivity curve of a student who does not complete a thesis and returns to the Fleet earlier. One goal of this thesis is to quantify the relevant costs and benefits associated with the thesis requirement as discussed in Figure 2.2.

THIS PAGE INTENTIONALLY LEFT BLANK

III. THE BENEFITS OF THE THESIS REQUIREMENT

A. INTRODUCTION

This chapter will examine the components included in the benefits of the thesis requirement. In general terms these benefits can be considered direct and indirect. Direct benefits are found in the educational value of the thesis process. These direct benefits will vary depending on the individual student, his or her duties following NPS, and the amount of time spent on active duty after graduating from NPS. As will be discussed, the direct benefits of the thesis experience cannot be quantified. Indirect benefits include the monetary value of NPS thesis research to the DoD. In order to uniformly compare benefits with costs, this chapter will be concerned largely with the benefits of the thesis requirement for one fiscal year (FY)--FY2000.

B. DIRECT BENEFIT

The direct benefit of the thesis requirement, as defined in this thesis, is the value of the increased productivity of graduates due to having completed a thesis. This direct benefit accrues to the DoD from the time the student graduates from NPS until he or she leaves the service.

Three considerations, discussed below, make it nearly impossible to accurately quantify these direct benefits. These considerations, or limitations, can be illustrated by revisiting Figure 2.2 from Chapter Two. Figure 2.2 is reproduced and simplified below as Figure 3.1. In this figure, the shaded area bounded by points C, F, and G represents the direct benefits of the thesis requirement. Time T represents the end of an officer's

service to the DoD. (DoD policy dictates that officers remain on active duty for at least three years following the completion of a funded graduate degree program. Thus, time T must be at least three years after completion of the degree program.) The lower (dashed) curve represents the productivity of a graduate who was not required to complete a thesis. The upper (solid) curve represents the productivity of a graduate who did complete a thesis.

Before turning to Figure 3.1 to illustrate the limitations of measuring direct benefits, the reader is reminded that the slopes and intercepts of these curves are hypothetical and only intended to illustrate the theory involved. It should also be recalled that, from the standpoint of the DoD, the student has no standing in the economic discussion of the thesis requirement. It is for this reason that the benefits of the thesis experience end at the moment the officer leaves the service. Further, it must be stressed that the area bounded by points C, F, and G represents only the added value that accrues to the DoD by having an officer complete a thesis. It is not the added value of the master's degree as a whole.

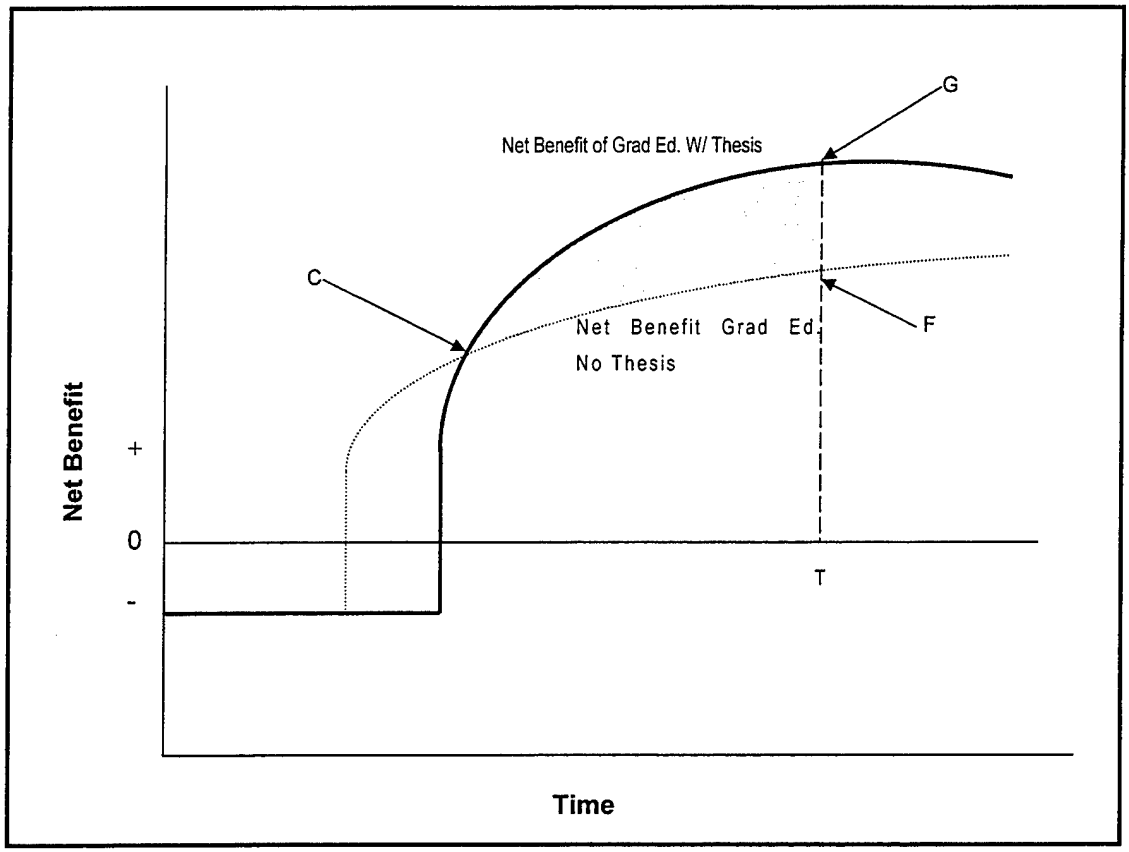

Figure 3.1. The Direct Benefit of the Thesis Requirement
Source: Text

1. The Limitations to Measuring Direct Benefits

First, if we consider all graduates of a given year--this thesis is concerned with FY2000--we must allow that some graduates will leave active service at the first opportunity after graduating from NPS (i.e., three or four years after graduating) while others may continue their careers out to twenty years, or even more, after graduation. Therefore, the first limitation is that we cannot accurately determine or predict where time T will fall in the model of direct benefits shown in Figure 3.1. The individual career lengths of NPS graduates will vary and cannot be predicted consistently enough to evaluate the benefit to the DoD of any particular aspect of NPS curricula. Obviously, if

the thesis experience results in a more productive officer, the value of that benefit to the DoD will depend on how long the officer stays in the service.

Second, the direct benefits realized by the DoD by having an officer complete a thesis will be affected by the duties that officer assumes after graduation. It is feasible that some billets may draw on and exploit the skills learned during the thesis experience thus returning a larger benefit to the DoD. Other duties, however, may allow for no added productivity due to the officer having completed a thesis. These would be types of jobs that do not rely heavily on critical analysis skills. The second limitation, then, is the impossibility of reliably measuring the slope of the productivity line representing the officer who completed a thesis.

Finally, and most significantly, while many studies have sought to determine the productivity increase of workers who complete graduate education, this author could find no available literature addressing productivity increases arising form only *portions* of a graduate degree program--such as a thesis requirement. Without a satisfactory measure of the marginal increase in productivity, due specifically to having completed a thesis, it is not possible to quantify the direct benefits of thesis work. The third limitation, therefore, is the lack of data on the relative distance between the productivity line of a student who does not complete a thesis and the productivity line of one who does.

Although the direct benefits of the thesis requirement are not quantified here, it is reasonable to assume that they exist and may be substantial. Direct benefits will be discussed further in Chapter 5.

2. Discounting of Direct Benefits

Before leaving the topic of the direct benefits of the thesis experience, a brief discussion of discounting is necessary. Discounting accounts for the fact that a rational person or organization would rather receive something of value now than in the future. The further in the future that something of value is received, the less its present value. The concept of discounting is usually applied to money but is equally valid when discussing anything of value.

Figure 3.2 below magnifies the area depicting direct benefits accruing to the DoD due to having an officer complete a thesis. It includes a time line intended to represent the career of two hypothetical NPS students who graduated in 2000 and leave the service in 2010. As previously discussed, the shaded area represents the direct value of the thesis and will manifest itself in the form of a more productive officer as a result of having done a thesis. Notice, though, that all the benefits do not accrue to the DoD immediately after the officer graduates. For this reason, the stream of benefits stretching out to 2010 must be discounted back to FY2000.

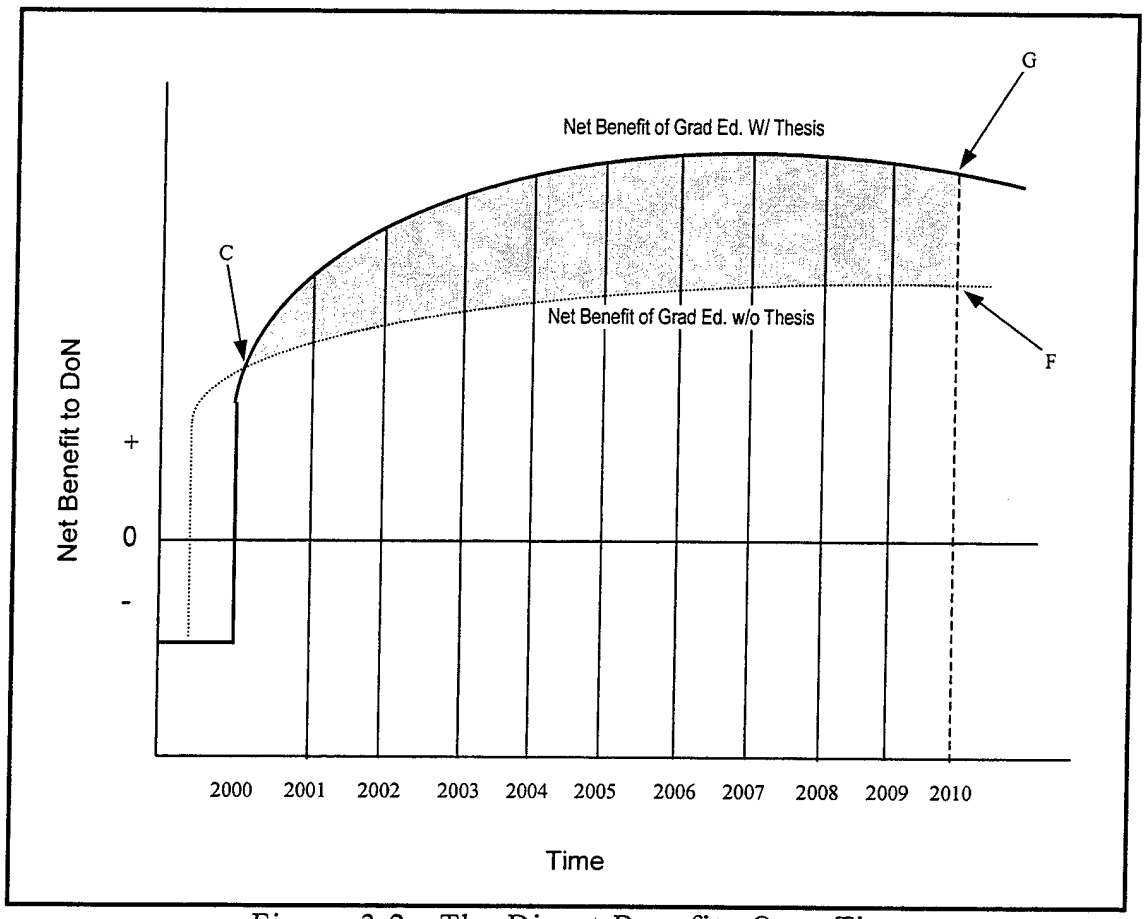

Figure 3.2. The Direct Benefits Over Time
Source: Text

The formula used to determine the present value of the future stream of benefits, from 2001 to end of service in 2010, is shown below.

$$PV = \sum_{t=1}^{10} B_t/(1 + i)^t$$

where PV = the present value of the future monetary amount of benefits resulting from completing a thesis,

B_t = the monetary benefit (i.e., the shaded area) in year t--in the form of increased productivity as a result of having completed a thesis, and

i = the discount rate.

Since, as discussed in the previous section, the value of the shaded area in Figure 3.2 is impossible to determine, it is impossible to accurately determine the present value of the increased productivity. It must be recognized, however, that when setting all costs and benefits in terms of the year of graduation, as this thesis does, any benefits or costs accruing in the future will have to be discounted.

C. INDIRECT BENEFITS

1. Willingness To Pay

When conducting cost-benefit analysis, it is necessary to determine the value of benefits and costs in monetary terms. In economic theory the concept of "willingness-to-pay" is used to measure the benefit of a program or service. Where free and functioning competitive markets exist, willingness-to-pay can be determined from the appropriate demand curve. Figure 3.3 shows how, in a competitive market, the value of a good can be determined by reading the equilibrium price from the point where the supply and demand curves intersect.

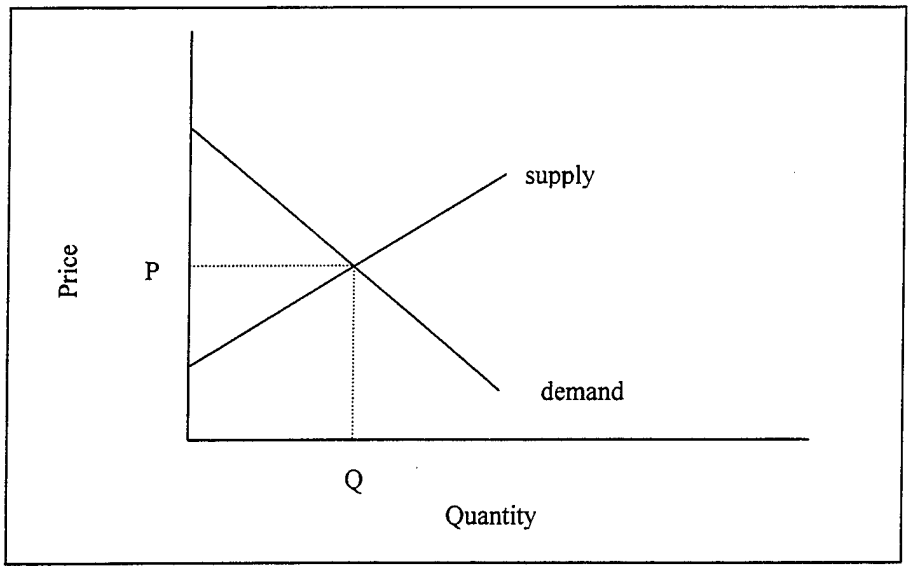

Figure 3.3. Supply and Demand in a Free and Functioning Market
Source: From Ref. 17

Given the supply and demand curves in Figure 3.3, a quantity of Q will be demanded at a price of P per unit. The market is said to be in equilibrium when goods are exchanged at the price and quantity determined by the intersection of the supply and demand curves. The principle of diminishing marginal utility accounts for the downward slope of the demand curve. Each additional unit of the good is valued slightly less highly by a consumer than the preceding unit. For this reason, a consumer is willing to pay less for another unit than for the preceding unit. [Ref. 1: p. 53]

Figure 3.4 below shows how the consumer would be willing to pay a price of P^* per item for X^* quantity of a good. The total expenditure required to obtain a quantity of X^*, therefore, is the product resulting from multiplying P^* by X^*. This total expenditure is represented in Figure 3.4 by the dark rectangle.

Notice, though, that the consumer would have been willing to pay P_1 for a quantity of one and P_2 for a quantity of two. In other words, the gross value to the

consumer of purchasing the quantity of X^* is the area under the demand curve out to the quantity purchased (X^* in this case). This gross value, or benefit, is shown in Figure 3.4 as the sum of the areas contained in the lightly shaded triangle and the darker shaded rectangle.

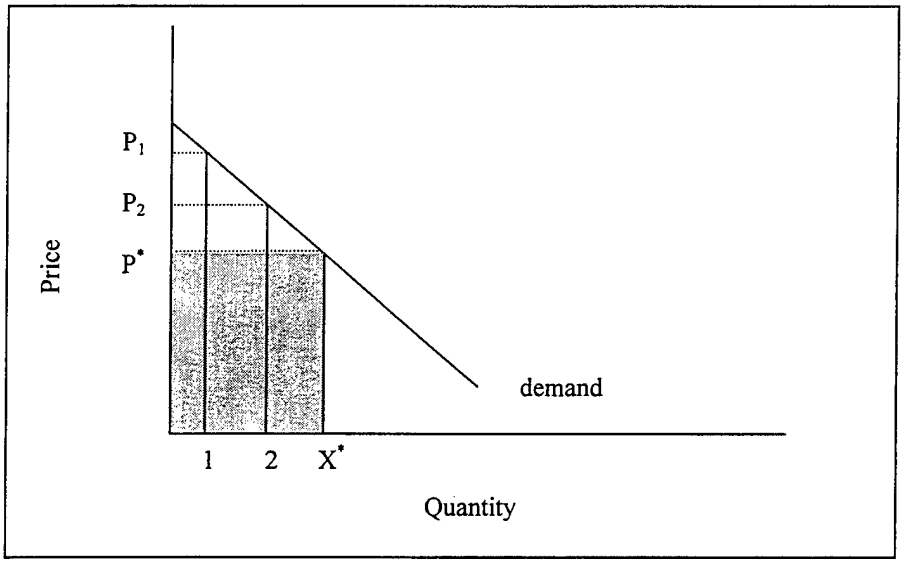

Figure 3.4. Consumer Gross Benefits and Consumer Surplus
Source: From Ref. 1

Subtracting the total expenditure required to obtain a quantity of X^* (the darker rectangle) from the gross benefit obtained by the purchase leaves a net benefit to the consumer of the area below the demand curve but above the price line. This area, known as consumer surplus, is shown graphically as the shaded triangle in Figure 3.5 below. The consumer surplus can be thought of as the amount the consumer would have been willing to pay for a particular quantity of a good but did not have to.

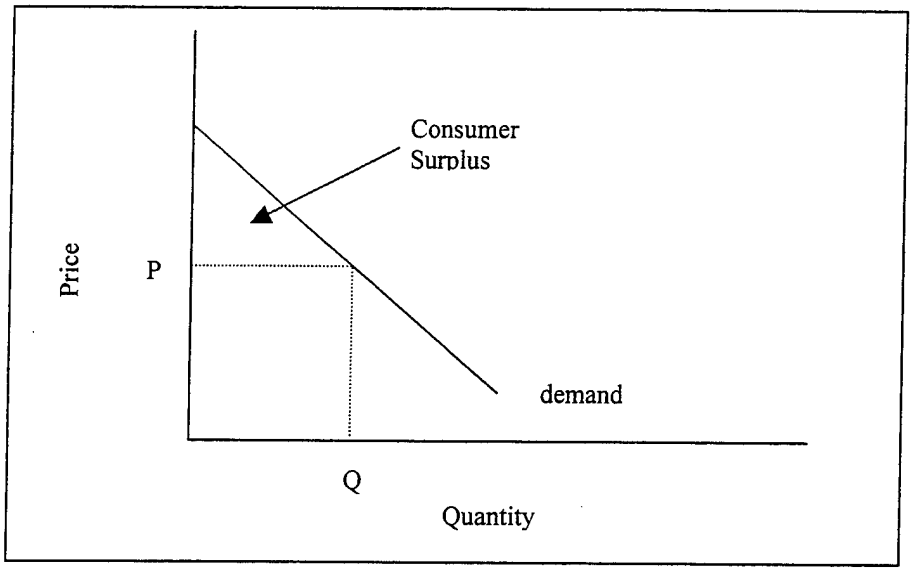

Figure 3.5. Consumer Surplus
Source: From Ref. 1

With this concept in mind, an ideal way to determine the value of research conducted by graduate students would be to determine what the DoD would be willing to pay for this research. An examination of the market's supply curve and the DoD's demand curve for theses written by graduate students would indicate an equilibrium price and quantity of theses. The DoD's willingness to pay for thesis production could then be easily determined by examining the area below the demand curve but above the price line (the shaded triangle in Figure 3.5). Unfortunately, many considerations combine to invalidate such a straightforward analysis in this case.

First, the supply curve for NPS theses is vertical. The number of theses produced does not respond to changes in market price (assuming a "price" for graduate students' theses can even be determined). Rather, the number of theses produced is purely a function of the number of students attending NPS at any given time, which in principle is determined by billet requirements. Second, since the DoD has shown little interest in

purchasing the research of graduate students, it can be said that the market for such research does not exist. In other words, there is no identifiable demand curve. Finally, and perhaps the most significant yet subtle point, for the purposes of the cost-benefit analysis, the DoD and NPS can be considered to be the same entity. It is the DoD that ultimately bears the expense and reaps the reward of the production of research via student theses.

Consequently, an alternate approach must be developed to determine the value of NPS theses to the Department of Defense. In cases in which observed prices fail to accurately reflect the social value of a good or observed prices do not exist, an approach called shadow pricing is often used in measuring benefits. [Ref. 1: p. 52] This thesis will use a market analogy method in an attempt to determine the shadow price (economic benefits) of NPS theses to the DoD.

2. The Market Analogy Method of Valuing Theses

Among the indirect benefits of NPS theses are their contribution of relevant research to the DoD and DoN. The DoD frequently contracts with private and non-profit organizations such as the Center for Naval Analyses (CNA) and the Rand Corporation to conduct research into various topics. Many theses at NPS, due to their subject matter and quality, reduce the need for the DoD to contract out such research.

> Some theses have resulted in large savings for the Navy. Others have introduced important new ideas that have had immediate effect on combat effectiveness. For example, *Challenge Athena*, which demonstrated a dramatic improvement in the ability of commercial satellites to provide essential, high bandwidth communication to Navy ships, was developed in a (classified) NPS thesis. [Ref. 11: p. 8]

Quality research that reduces the DoD's reliance on external agencies saves the DoD money and can be considered an indirect benefit of the thesis requirement at NPS.

If one accepts that many NPS theses provide valuable research to the DoD, then it is reasonable to consider these theses as substitutes, or analogous goods, for analysis and research that might otherwise be contracted out to organizations such as CNA or Rand. In cost-benefit analysis one "can use prices in analogous markets as a measure of the value of the publicly provided good or we can use price and quantity information to estimate a demand curve for the publicly provided good." [Ref. 1: p. 309]

This thesis will therefore consider CNA and Rand research projects to be goods analogous to NPS theses. This market analogy method, while not perfect, overcomes the three barriers to determining the DoD's willingness to pay for thesis work as mentioned in the previous section (vertical supply curve, unidentifiable demand curve, and identical buyer and seller).

Before attempting to monetize the value of student research by comparing it to research performed by organizations such as CNA or Rand, it must be recognized that some theses produced at NPS have little or no direct research value to the DoD. Further, even if a particular thesis does have value to the DoD, one must acknowledge a possible difference in quality of work as compared to Rand or CNA. As pointed out in Chapter Two, the primary purpose of the thesis requirement is not to produce valuable research for the DoD or DoN. Rather, the primary purpose is to train and evaluate the student. It is proper then to assume that thesis research performed by NPS students is not always comparable, in quality, scope, or impact to research performed by analysts at CNA or

Rand—many of whom possess doctoral degrees and are experienced researchers. It is possible, therefore, that comparing NPS theses with CNA studies will overstate the indirect value of the NPS thesis.

While many NPS theses are valuable to the DoD, many are not. In a 1998 memo, the NPS "Thesis on the Internet" committee found that "some theses, while they might be regarded as good learning experiences for the thesis students, make no contribution to the state-of-the-art...." [Ref. 21: p. 2] The committee also noted "some theses may be of such poor quality as to embarrass NPS if made widely available." [Ref. 21: p. 2] (It should be noted, however, that even a thesis of poor quality may contribute substantially to the author's educational experience—i.e., have a *direct* benefit. Conversely, it is possible that a thesis with immense indirect payoff to the DoD may not have contributed much to the author's educational experience.)

In order to estimate which theses have the potential to contribute meaningful and quality research to the DoD and which make no contribution, the NPS Research Office conducts a survey of all thesis advisors. Since 1997, the NPS Research Office has asked all faculty advisors the question, "Are the results of (this) thesis of value to the Fleet?" In FY2000, there were 641 responses out of 680 total theses completed—a response rate of 94.3 percent. Of the 641 respondents, 380, or 59.3 percent, reported in the affirmative. [Ref. 5]

Assuming that 59.3 percent of the theses had some value to the DoD, the question becomes, "What is the monetary value of those that were deemed useful?" To answer this, we now combine the concepts of "willingness-to-pay" and market analogy.

3. Monetizing the Benefit of Thesis Research

By using CNA and Rand research reports as analogous goods to the NPS thesis, one can develop a shadow price of the thesis. The approach taken below is to estimate how much time it would take a CNA or Rand analyst to produce a report similar in scope to a typical NPS thesis and then determine the monetary value of that time based on the salary of the analyst. The final step is a multiplication of this monetary value of a single Rand or CNA research report by the total number of useful theses produced in FY2000 (380).

Through phone conversations and emails with personnel at the N-13 branch (Military Personnel Plans and Policy Division) of the Navy's Bureau of Personnel (BUPERS), lower and upper bounds have been determined for the time it takes a Rand or CNA analysts to produce a research report similar in scope to an NPS thesis. This thesis will use 40 days as a lower bound and 70.6 days as an upper bound. [Refs. 8 & 16] As will be discussed in Chapter Four, this thesis uses an estimate of 70.6 days required for an NPS student to complete a thesis. This figure is used as the upper bound based on the assumption that a professional analyst would require no more time than an NPS student to complete a similar project.

It has been determined that lower limit cost for research production at CNA or Rand is $200,000 per man-year (that is, one person working one year). The upper limit is approximately $250,000 per man-year. [Refs. 8 & 16] These figures include the salary of the analyst and a certain amount of overhead expenses.

With the above information, we can now determine an upper and lower bound on the cost per CNA or Rand research project—i.e., the shadow price of the useful NPS theses produced in FY2000. Multiplying this cost per project by the number of useful theses produced in FY2000 will give a shadow price of the indirect benefit of thesis production to the DoD.

The first step, determining an upper and lower bound on the cost per CNA or Rand research report, is shown in Table 3.1 below.

	Days Required	Proportion of a Year	Annual Salary	Total Cost
Upper Bound	70.6	.193425	$250,000	$48,356
Lower Bound	40	.109589	$200,000	$21,918

Table 3.1. Upper and Lower Bound for Cost of CNA or Rand Research Report
Source: Text

Simply multiplying the upper and lower bounds of the cost per report by the number of useful theses produced in FY2000 (380) returns a range within which we can expect to find the total indirect value of the theses for the year. That range is $8,328,767 (380 x $21,918) to $18,375,342 (380 x $48,356).

Due to the possible differences in quality of work discussed above, it is considered unlikely that indirect benefits in FY2000 approached the upper bound of $18,375,342. It is presumed that the indirect benefits of NPS student research are closer to the lower bound of the value of professional research.

D. SUMMARY OF BENEFITS

In the preceding sections, it was determined that the DoD enjoyed a indirect benefit of around $8,328,767, but possibly up to $18,375,342, in FY2000 due to the research conducted by NPS students. While the direct benefits, in the form of a more productive officer for having done a thesis, are presumably positive and possibly significant, they cannot be monetized.

IV. THE COSTS OF THE THESIS REQUIREMENT

A. INTRODUCTION

This chapter will examine the components included in the cost of the thesis requirement. In general terms these costs can be considered indirect and direct. Indirect costs include the opportunity cost of the officer/student's time spent working on the thesis as well as the time of the thesis advisors.

Direct costs include all costs other than the students' and advisors' time associated with the thesis requirement. Activities such as processing, printing, and cataloging of theses fall into this category. Additionally, the costs of government-funded travel in conjunction with thesis research can be considered a direct cost of the thesis requirement. While sponsors outside of NPS frequently reimburse travel costs, these costs are still expenses to the DoD associated with the theses requirement. In order to uniformly compare benefits with costs, this chapter will be concerned with the costs of the thesis requirement for one fiscal year (FY)--FY2000.

B. DIRECT COSTS

There are three broad categories of direct costs: thesis processing expenses, thesis travel expenses, and theses cataloging and storage expenses. Each of these categories will be discussed below.

1. Thesis Processing Expenses

The Research Office at NPS spent $120,502 on thesis processing in FY2000. A breakout of the $120,502 is included in table 4.1 below.

Labor	$80,502
Printing	$40,000
TOTAL PROCESSING COST	**$120,502**

Table 4.1. Total Thesis Processing Expense (FY2000)
Source: Ref. 14

2. Thesis Travel Expenses

Each year, many students take government-funded trips in conjunction with their thesis research. The cost of these trips is a direct cost of the thesis requirement. The NPS comptroller reported that, in FY2000, there were 250 sets of travel orders issued in support of thesis work. These travel orders totaled $178,400 for FY2000. [Ref. 4] The comptroller further indicated that this number of trips and total expense is normal—in other words, FY2000 was not an anomaly as far as thesis travel was concerned.

3. Thesis Cataloging, Storing, and Binding Expenses

The expenses of cataloging, storage, and binding theses are variable costs associated with the thesis requirement that are incurred at the Dudley Knox Library at NPS. These expenses reflect the time and effort devoted to new theses each year. Of course, regardless of whether or not the thesis requirement remains in place, the library will continue to maintain its collection of past theses. Therefore, care has been taken to

only include the costs of cataloging and storing *new* theses each year (i.e., only variable costs).

The Knox Library kept detailed records of time devoted to cataloging, storing, and binding the theses received in 1999. According to the NPS Research Office, there were 597 theses completed in 1999. Table 4.2 shows the labor expenses, by activity, associated with cataloging and storing the 597 theses received by the Library in FY99.

Activity	Total Time (hours)	FY99 Salary (per hour)	Total Cost
Coordinate w/ Thesis Office	4	$21.49	$86
Cataloging	271	$21.49	$5,824
Cataloging Classified	40	$21.95	$878
Processing	90	$21.49	$1,934
Shelving (Tech Services)	42	$21.49	$903
Shelving (Laborer)	253	$18.10	$4,579
Prepare Binding	90	$21.49	$1,934
Check-in Bound Titles	125	$21.49	$2,686
		Total Labor Expense	**$18,824**

Table 4.2. Thesis Cataloging and Storage Labor Expense (FY99)
Source: Ref. 24

Dividing the $18,824 of total labor cost by the number of new theses handled in FY1999 (597) yields an average labor expense, per thesis, of $31.53 in FY99. In order to convert this the proper rate for FY2000, the 4.8 percent federal pay raise is added to the $31.53 average labor cost. This results in an average labor cost of $33.04. In order to determine the cost of labor for FY2000, one can multiply the average labor cost of $33.04 by the number of theses completed in FY2000. The NPS Research Office reported that

there were 680 theses completed in FY2000. The total labor cost, therefore, for FY2000 for cataloging, storage, and binding was $22,467 ($33.04 x 680).

Separate from the labor cost discussed above are the costs of binding archival copies of each thesis. In FY2000 it cost $7.50 per thesis for binding. [Ref. 25] Multiplying this cost by the number of theses completed yields a total cost for binding of $5,100 ($7.50 x 680) in FY2000. Therefore, the total expenses for cataloging, storing, and binding theses in FY2000 were the labor expense of $22,467 plus the binding expense of $5,100. That sum was $27,567.

C. INDIRECT COSTS

A large portion of the overall cost of the thesis requirement is the opportunity cost of the students' time spent working on the thesis. "The concept of opportunity cost is used in cost-benefit analysis to place a dollar value on the inputs required to implement policies. The opportunity cost of using an input to implement a policy is its value in its best alternative use." [Ref. 1: p. 31] In this thesis, the thesis requirement is the policy under debate and the officers and, to a lesser degree, faculty members are the inputs required for implementation.

As discussed in Chapter Two, while attending NPS, students continue to receive full pay and benefits even though they are not "producing" national defense. That is, while assigned as a student at NPS, an officer is not performing in the duty and billet for which he was trained, yet his cost to the Department of Defense remains as if he were.

Again revisiting Figure 2.2 from Chapter Two, we can see the hypothetical area of this opportunity cost. In Figure 4.1 below, the opportunity cost of students staying at NPS in order to complete a thesis is represented by the shaded area bounded by points A, B, and C.

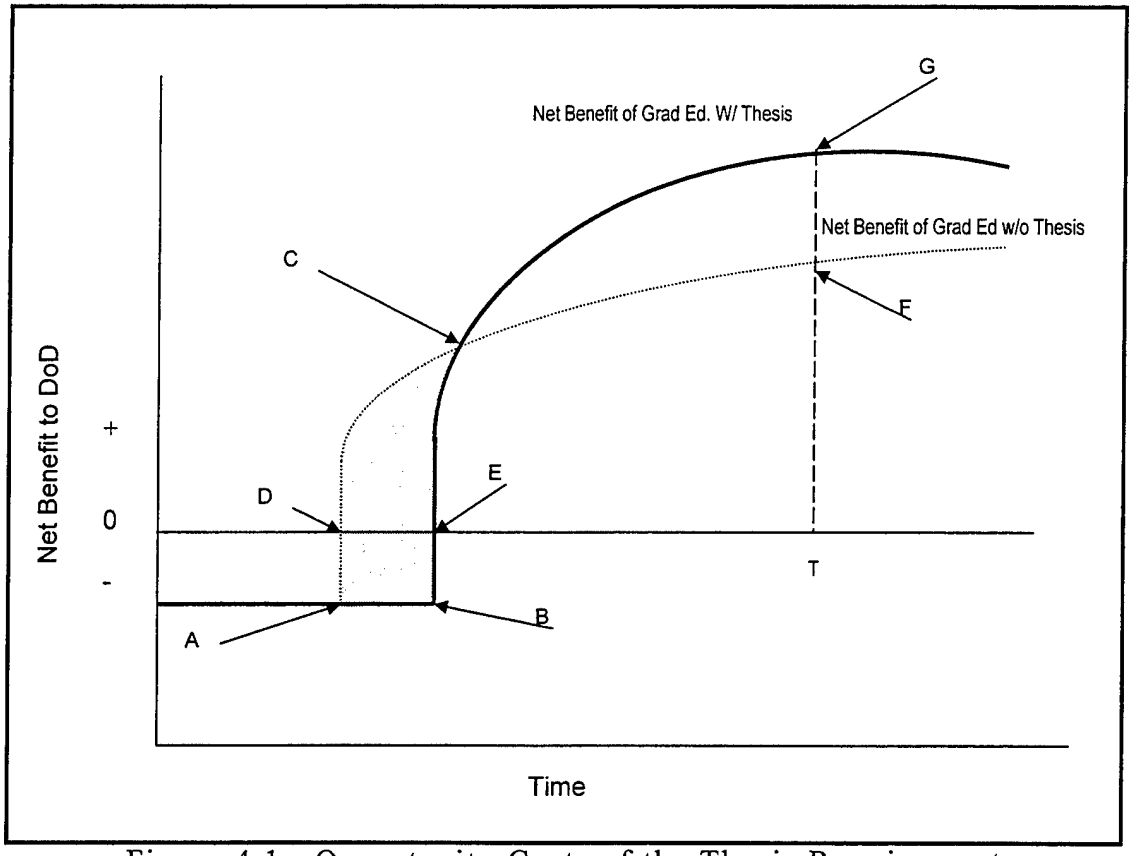

Figure 4.1. Opportunity Costs of the Thesis Requirement
Source: Text

The following paragraphs will develop a method for monetizing this negative net productivity. Once the opportunity cost of the student's time has been identified, similar techniques will be used to determine the opportunity cost of faculty time spent advising students on their theses.

1. Opportunity Cost of Students' Time

There are three components that, when multiplied together, determine the opportunity cost of students' time devoted to thesis work during a fiscal year: 1) The number of students, by paygrade and service, who completed a thesis during the fiscal year; 2) The monetary value of time for each officer, by paygrade and service; and 3) The amount of time each student devoted to thesis work. Each of these components will now be identified and discussed for FY2000's graduates.

The demographics (i.e., services and paygrades) of students that graduated during FY2000 are shown in Table 4.3. These numbers do not include international students or civilians.* In addition, the small number of U.S. Coast Guard officers and U.S. Army Reserve and National Guard officers are included in the demographics for the Navy and Army, respectively.

Grade	Army	Air Force	Marine Corps	Navy	Total
O-1	0	2	0	31	33
O-2	1	3	0	4	8
O-3	45	10	41	243	339
O-4	16	5	43	97	161
O-5	3	0	1	6	10
Total	65	20	85	381	551

Table 4.3. Pay Grade and Service of FY2000 NPS Graduates
Source: Ref. 12

* International students and civilians are not included in this discussion because they are not considered to have "standing" in the economic discussion of curricula requirements at NPS. This is because their "tuition" and opportunity cost to be at NPS and complete a thesis are not borne by the DoD.

An appropriate measure of the value of an officer's time when in training is the Military Composite Standard Pay and Reimbursable Rate (MCSPRR) for that officer's rank and service. Each year the Department of Defense Comptroller computes MCSPRRs for each service branch and paygrade. These metrics, which include pay and benefits, are used by non-defense federal agencies to determine the cost of temporarily assigned military officers who are performing general skills tasks unrelated to their warfare specialty. [Ref. 2: p. 43] Military Composite Standard Pay and Reimbursable Rates can be used to monetize the value of an officer's time spent on, among other things, working on a thesis. Appendix A contains the rates for each branch of service for Fiscal Year 2000. (These rates can be found on the World Wide Web at: http://www.dtic.mil/comptroller/rates/2000_k1.pdf.)

The rates shown in Appendix A are annual rates. The DoD Comptroller provides scalar of .00439 to be used to convert annual rates into daily rates. For example, a Navy Lieutenant (O-3) had an annual MCSPRR of $86,050 for FY2000. The daily rate can be computed by multiplying $86,050 by .00439. Therefore, the daily rate for a Navy Lieutenant was $377.76 in FY2000.

Similarly, hourly rates can be computed using a scalar of .00055. Again using the example of a Navy Lieutenant (O-3) with an annual MCSPRR of $86,050 for FY2000. The hourly rate can be computed by multiplying $86,050 by .00055. Therefore, the hourly rate for a Navy Lieutenant was $47.33 in FY2000.

There are two techniques that can be used to determine the opportunity cost of students' time devoted to thesis work. The first technique for determining students'

opportunity cost, and one that will be used for this cost analysis, involves estimating the number of days students spend on thesis work and multiplying that estimate by the appropriate daily MCSPRR for each students' service and paygrade. Summing these results for all students will produce an estimated monetary value of time spent on thesis work.

A second technique for determining students' opportunity cost is to analyze the results of a survey given to students by the NPS Research Office. This survey seeks to determine the amount of time students self-report that they spent on thesis work. For reasons discussed later, this technique was rejected.

Either technique is subject to sensitivity analysis. Of the three components of the opportunity cost of students' time—the number of students by rank and service, the monetary value of time by rank and service, and the number of days or hours devoted to thesis work--only the latter, time devoted to thesis work, is appropriate for sensitivity analysis. The number of students that graduated in FY2000, by service and paygrade, and the Military Composite Standard Pay and Reimbursable Rates for FY2000, are known parameters.

a. Estimate of Opportunity Cost Based on Time Allotted for Thesis Work

Appendix B shows the length of time, in months, of each curriculum at NPS. The appendix also shows the number of thesis blocks allotted to each curriculum. (Appendix B is a compilation of data contained in the Naval Postgraduate School General Catalog for Academic Year 2000.) Of the fifty curricula that require a thesis, the average

number of thesis blocks allotted is 3.53. Since the normal required course load in a quarter is four and one thesis block is equivalent to a course, the average proportion of a quarter that is allotted strictly for thesis work is .8825 (3.53 ÷ 4). In other words, over the course of degree work at NPS, the school formally allows, on average, .8825 of a quarter to complete a thesis.

A normal quarter at NPS is approximately 80 days. Therefore, if NPS allows .8825 of a quarter strictly for thesis work and a quarter is 80 days, the number of days allocated to thesis work is 70.6 (80 x .8825). (It could be argued that only the number of working days per quarter [approximately 60] is the more appropriate figure to use when estimating time spent on NPS work. It is rejected in this case because, in theory, elimination of the thesis requirement would allow students to return to operational duties 80 days earlier than if the requirement remained in place. The time saved by not being at NPS would include weekends and holidays.)

By multiplying the number of FY2000 NPS graduates of each service and paygrade by the average number of days allotted to working on the thesis, one can derive an estimate of the total days devoted to thesis work, by service and paygrade. This product, when multiplied by the appropriate MCSPRR for each service and paygrade, gives an estimated total monetized value of the time devoted to thesis work in FY2000.

Tables 4.4 through 4.7 show the results of these computations by service branch.

Navy Officers						
Pay Grade	# of graduates	MCSPRR	Daily Scalar	Daily Rate	Average Days Working on Thesis	Total Cost by Paygrade
O-1	31	$53,175	.00439	$233.44	70.6	$510,903
O-2	4	$66,925	.00439	$293.80	70.6	$82,969
O-3	243	$86,050	.00439	$377.76	70.6	$6,480,766
O-4	97	$98,775	.00439	$433.62	70.6	$2,969,532
O-5	6	$115,450	.00439	$506.83	70.6	$214,691
					TOTAL COST FOR SERVICE BRANCH	**$10,258,861**

Table 4.4. Estimated cost of time devoted to thesis work by Navy officers graduating in FY2000.
Source: Text

Marine Corps Officers						
Pay Grade	# of graduates	MCSPRR	Daily Scalar	Daily Rate	Average Days Working on Thesis	Total Cost by Paygrade
O-1	0	$50,225	0.00439	$220.49	70.6	$0
O-2	0	$62,850	0.00439	$275.91	70.6	$0
O-3	41	$76,675	0.00439	$336.60	70.6	$974,332
O-4	43	$92,075	0.00439	$404.21	70.6	$1,227,098
O-5	1	$110,875	0.00439	$486.74	70.6	$34,364
					TOTAL COST FOR SERVICE BRANCH	**$2,235,794**

Table 4.5. Estimated cost of time devoted to thesis work by Marine Corps officers graduating in FY2000.
Source: Text

Army Officers						
Pay Grade	# of graduates	MCSPRR	Daily Scalar	Daily Rate	Average Days Working on Thesis	Total Cost by Paygrade
O-1	0	$45,050	0.00439	$197.77	70.6	$0
O-2	1	$58,925	0.00439	$258.68	70.6	$18,263
O-3	45	$77,900	0.00439	$341.98	70.6	$1,086,474
O-4	16	$94,025	0.00439	$412.77	70.6	$466,265
O-5	3	$111,650	0.00439	$490.14	70.6	$103,812
					TOTAL COST FOR SERVICE BRANCH	**$1,674,814**

Table 4.6. Estimated cost of time devoted to thesis work by Army officers graduating in FY2000.
Source: Text

Air Force Officers						
Pay Grade	# of graduates	MCSPRR	Daily Scalar	Daily Rate	Average Days Working on Thesis	Total Cost by Paygrade
O-1	2	$46,275	0.00439	$203.15	70.6	$28,684
O-2	3	$60,650	0.00439	$266.25	70.6	$56,392
O-3	10	$82,025	0.00439	$360.09	70.6	$254,223
O-4	5	$99,625	0.00439	$437.35	70.6	$154,386
O-5	0	$115,250	0.00439	$505.95	70.6	$0
					TOTAL COST FOR SERVICE BRANCH	**$493,685**

Table 4.7. Estimated cost of time devoted to thesis work by Air Force officers graduating in FY2000.
Source: Text

A summation of the estimated total cost for each service branch gives an estimated total value of time spent on thesis work for all U.S. military students who graduated during FY2000.

This is shown in Table 4.8 below.

SERVICE	TOTAL COST
Navy	$10,258,861
Marine Corps	$2,235,794
Army	$1,674,814
Air Force	$493,685
ESTIMATED TOTAL COST	**$14,663,154**

Table 4.8. Estimated total opportunity cost of time spent on theses in FY2000
Source: Text

As mentioned above, the one factor subject to sensitivity analysis is the amount of time the FY2000 graduates spent on thesis work. The above example assumes that all graduates of FY2000 spent 70.6 days on thesis work. A change of plus or minus one day in that estimate results in a change of plus or minus $207,694 in total opportunity costs based on the demographics of the FY2000 graduates. There is a linear relationship between the total opportunity costs and the number of days spent on thesis work.

b. Estimate of Opportunity Cost Based on Student Survey

Since the winter quarter of 1999 (the first quarter of FY2000), all NPS graduates have been asked to estimate the number of hours in an average week that they worked on their thesis and to estimate the number of weeks that they worked on their thesis. [Ref. 6] The product of each individual's two estimates represents the estimated total hours that the individual devoted to thesis work. Ideally, this self-reported number of hours would give an accurate indication of the amount of time devoted to thesis work.

This measure was rejected due to the suspiciously high amount of time students self-report that they work on their theses.

Although rejected as a technique to determine time spent on thesis work, the survey results are included here for two reasons. First, the survey could be a great tool for determining a more realistic estimate amount of time spent on thesis work. Improved questions that include some form of a "grounding reference" to help students accurately recall their thesis work might generate more reliable and valid results.* Second, the reader of this thesis will likely find it interesting to see the amount of time students self-report they devoted to thesis work and, therefore, the total opportunity cost associated with this metric.

The results of 782 responses to the survey are summarized in Table 4.9 below.

–1 Standard Deviation	424.47
Mean	801.35
+1 Standard Deviation	1178.23
Standard Deviation	376.88

Table 4.9 Hours Devoted To Thesis Work
Source: From Ref. 5

The remainder of this section will develop the opportunity cost of students' time devoted to thesis work using these self-reported numbers.

* The format of the current survey may result in biased responses since the survey is given right after a student completes his or her thesis. The timing of the survey may cause students to overestimate the actual amount of time they spent on thesis work. Further, the questions involved—How many hours per week did you work on your thesis? and How many weeks did you work on your thesis?—make it difficult for a survey respondent to indicate the total number of hours devoted to thesis work.

By multiplying the number of FY2000 NPS graduates of each service and paygrade by the average number of hours spent working on the thesis, one can derive an estimate of the total hours devoted to thesis work, by service and paygrade. This product, when multiplied by the appropriate MCSPRR for each service and paygrade, gives an estimated total monetized value of the time devoted to thesis work in FY2000.

Tables 4.10 through 4.13 show the results of these computations by service branch.

Navy Officers						
Pay Grade	# of graduates	MCSPRR	Hourly Scalar	Hourly Rate	Average Hours Working on Thesis	Total Cost by Paygrade
O-1	31	$53,175	0.00055	$29.25	801.35	$726,531
O-2	4	$66,925	0.00055	$36.81	801.35	$117,987
O-3	243	$86,050	0.00055	$47.33	801.35	$9,215,992
O-4	97	$98,775	0.00055	$54.33	801.35	$4,222,831
O-5	6	$115,450	0.00055	$63.50	801.35	$305,302
TOTAL COST FOR SERVICE BRANCH						**$14,588,643**

Table 4.10. Estimated cost of time devoted to thesis work by Navy officers graduating in FY2000.
Source: Text

Marine Corps Officers						
Pay Grade	# of graduates	MCSPRR	Hourly Scalar	Hourly Rate	Average Hours Working on Thesis	Total Cost by Paygrade
O-1	0	$50,225	0.00055	$27.62	801.35	$0
O-2	0	$62,850	0.00055	$34.57	801.35	$0
O-3	41	$76,675	0.00055	$42.17	801.35	$1,385,551
O-4	43	$92,075	0.00055	$50.64	801.35	$1,744,999
O-5	1	$110,875	0.00055	$60.98	801.35	$48,867
					TOTAL COST FOR SERVICE BRANCH	**$3,179,417**

Table 4.11. Estimated cost of time devoted to thesis work by Marine Corps officers graduating in FY2000.
Source: Text

Army Officers						
Pay Grade	# of graduates	MCSPRR	Hourly Scalar	Hourly Rate	Average Hours Working on Thesis	Total Cost by Paygrade
O-1	0	$45,050	0.00055	$24.78	801.35	$0
O-2	1	$58,925	0.00055	$32.41	801.35	$25,971
O-3	45	$77,900	0.00055	$42.85	801.35	$1,545,023
O-4	16	$94,025	0.00055	$51.71	801.35	$663,053
O-5	3	$111,650	0.00055	$61.41	801.35	$147,627
					TOTAL COST FOR SERVICE BRANCH	**$2,381,674**

Table 4.12. Estimated cost of time devoted to thesis work by Army officers graduating in FY2000.
Source: Text

Air Force Officers						
Pay Grade	# of graduates	MCSPRR	Hourly Scalar	Hourly Rate	Average Hours Working on Thesis	Total Cost by Paygrade
O-1	2	$46,275	0.00055	$25.45	801.35	$40,791
O-2	3	$60,650	0.00055	$33.36	801.35	$80,193
O-3	10	$82,025	0.00055	$45.11	801.35	$361,519
O-4	5	$99,625	0.00055	$54.79	801.35	$219,545
O-5	0	$115,250	0.00055	$63.39	801.35	$0
TOTAL COST FOR SERVICE BRANCH						**$702,048**

Table 4.13. Estimated cost of time devoted to thesis work by Air Force officers graduating in FY2000.
Source: Text

A summation of the estimated total cost for each service branch gives an estimated total value of time spent on thesis work for all U.S. military students who graduated during FY2000.

This is shown in Table 4.14 below.

SERVICE	TOTAL COST
Navy	$14,588,643
Marine Corps	$3,179,417
Army	$2,381,674
Air Force	$702,048
ESTIMATED TOTAL COST	**$20,851,782**

Table 4.14. Estimated total opportunity cost of time spent on theses in FY2000
Source: Text

As mentioned above, the self-reported number of hours devoted to thesis work is suspiciously large. The average amount of time reported was approximately 800 hours. This would be the equivalent of a student working on his or her thesis eight hours

a day, five days a week, for five months. Anecdotal evidence suggests that practically no students do this.

Table 4.9 above includes the standard deviation (376.88 hours) from the mean estimated time spent on thesis work. The table also includes the value of the mean minus one standard deviation (424.47 hours) and the mean plus one standard deviation (1,178.23 hours). Table 4.15 below shows the estimated total opportunity costs that would be derived by substituting these values into tables 4.10 through 4.13.

Service Branch	Total Cost at Mean -1 StdDev (424.47 hours)	Total Cost at Mean (801.35 hours)	Total Cost at Mean +1 StdDev (1,178.23 hours)
Navy	$7,727,511	$14,588,643	$21,449,774
Marine Corps	$1,684,117	$3,179,417	$4,674,717
Army	$1,261,557	$2,381,674	$3,501,789
Air Force	$371,870	$702,048	$1,032,225
ESTIMATED TOTAL COST	**$11,045,055**	**$20,851,782**	**$30,658,505**

Table 4.15. Estimated Total Cost at the mean time spent on thesis and at mean +/- 1 Standard Deviation
Source: Text

The extraordinary amount of time students self-report is even more suspicious when one examines the distribution of responses to the survey questions gauging the number of hours devoted to thesis work. As the survey was designed, the maximum number of hours a student could indicate he or she devoted to thesis work was 1,440. (This value of 1,440, by the way, would mean the student worked on his or her thesis eight hours a day, five days a week for nine months!)

Figure 4.2 below is a histogram showing the distribution of responses. Notice that the mode, the most frequently reported response, is 1,440. This gives a strong

indication that many students would have chosen a response greater than 1,440 if given the opportunity by the survey. Such responses would have resulted in the mean number of hours devoted to thesis work being greater than 801.35. This in turn would result in an increase in the estimated opportunity cost of students' time to complete a thesis.

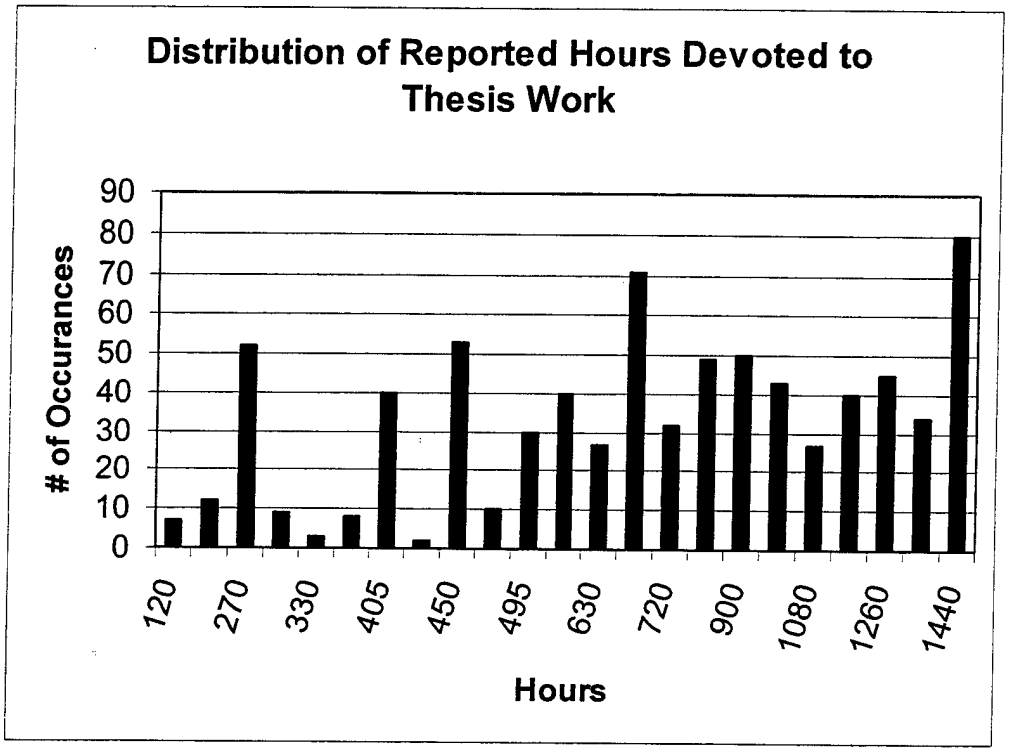

Figure 4.2. Distribution of Reported Hours Devoted to Thesis Work
Source: From Ref. 5

Due to the limitations of the survey mentioned above, and the location of the mode, one would surmise that the actual average time devoted to thesis work was greater than 801.35 hours. Therefore, using self-reported estimates would likely yield a value of students' time devoted to thesis work of somewhere between $20,851,782 and $30,658,505. This stands in contrast to the $14,663,154 estimate adopted in this thesis using the number of days allotted to thesis work and the average number of thesis blocks per curricula.

2. Opportunity Cost of Advisors' Time

Much like the opportunity cost of students' time devoted to thesis work, there is a cost associated with the time faculty members spend advising students on theses. By comparison to the difficulty in calculating the opportunity cost of student time, computation of faculty opportunity cost is relatively straightforward.

During Academic Year 1999, all NPS faculty members were surveyed by the Strategic Planning, Educational Assessment and Research (SPEAR) office in an effort to determine how faculty members spend their time. This survey of the entire population of 359 faculty members garnered 234 responses for a response rate of 65.2 percent. [Ref. 26] (Of the 359 faculty members, 72 were either on sabbatical, leave, or otherwise unable to respond.) The survey showed that, on average, NPS faculty members spend 12.31 percent of their time advising students on thesis work.

By multiplying each faculty member's estimate of the proportion of his or her time devoted to thesis advising by that particular faculty member's 1999 pay, one can monetize the opportunity cost of that faculty member's advising time. For example, if Professor X devoted 25 percent of his time to advising students on thesis matters and he earned $100,000 in 1999, the opportunity cost of his time devoted to thesis advising was $25,000 (.25 x $100,00). By performing these calculations for all 359 faculty members and then summing the results, one arrives at the total opportunity cost of faculty time devoted to thesis advising. In 1999 that amount was $4,577,896. The actual computations involved are not shown here to protect the privacy of faculty members.

These computations used a by-name roster of faculty, their estimate of time spent on thesis work, and their annual salary.*

In order to uniformly compare all costs and benefits, this thesis uses FY2000 figures. The FY1999 opportunity cost of faculty advisors' time can be adjusted to reflect the 4.8 percent pay raise for 2000. This adjustment gives an opportunity cost for FY2000 of $4,797,635.

D. SUMMARY OF COSTS

This chapter identified the various costs associated with the thesis requirement. In terms of FY2000 dollars, those costs are summed in table 4.16 below.

Opportunity Cost of Student Time	$14,663,154	
Opportunity Cost of Faculty Time	$4,797,635	
TOTAL INDIRECT COST		$19,460,789
Processing Cost	$120,502	
Thesis Travel Expense	$178,400	
Thesis Cataloging, Storing, and Binding	$27,567	
TOTAL DIRECT COST		$326,469
FY2000 COST OF THESIS REQUIREMENT		**$19,787,258**

Table 4.16. Total Cost of the Thesis Requirement for FY2000
Source: Text

* Of note, this estimate of faculty time spent advising theses is only an estimate. Faculty members were asked to recall how they spent their time each quarter for four quarters almost one year after the academic year had ended.

V. SENSITIVITY ANALYSIS

A. INTRODUCTION

This chapter highlights and discusses some of the uncertainties that entered into the calculations of economic benefits and costs in the previous two chapters. The previous two chapters relied on the author's best estimates for some unknown values (the number of days typically required for students to complete a thesis, for example). This chapter will examine how changes in assumptions will change the predicted costs and benefits of the thesis requirement. "Sensitivity analysis is a way of acknowledging uncertainty about the values of important parameters in our predictions." [Ref. 1: p. 187]

B. SENSITIVITY ANALYSIS OF THESIS COSTS

Before looking at values subject to variation, the concept of fixed, variable, and marginal costs, as they relate to thesis production, must be addressed. Fixed costs are those that do not vary with the number of theses produced. Variable costs, on the other hand, change as the quantity of theses produced changes. Total costs are simply the sum of fixed and variable costs. Finally, marginal costs represent the increase in total cost that is due to producing one more thesis. The sensitivity analysis in the next section will be focused on the marginal cost of thesis production.

A review of Chapter 4 shows that this thesis implicitly treats all costs associated with thesis production as variable. For any given year, if no new theses were written, there would be no fixed costs associated with thesis production. Students and faculty could immediately devote the time saved to other productive pursuits. In addition, thesis

processing would immediately cease as there would no longer be a need to print, catalog, and store new theses.

It could be argued that there might be some delay, and therefore fixed cost, before faculty members could be expected to fill the time saved by not advising on theses with other productive activities (or the faculty size be reduced). Similarly, it could be argued that the few people solely devoted to thesis processing would not be reassigned or eliminated immediately. These time delays, however, could potentially be so short as to make these costs variable for purposes of this research. It is also not clear what the other productive pursuits would be. Clearly, the integrative nature of the thesis as the culmination of a degree program might need to be accomplished in another way that would require faculty and staff time.

As mentioned above, sensitivity analysis is concerned with the marginal cost of thesis production. Since there are no fixed costs associated with producing new theses each year, and there is no evidence of any economies of scale, the marginal cost of producing one additional thesis is equal to the variable cost. In this case, the variable cost is also equal to the average cost (total cost divided by the number of theses produced).

In Chapter 4, the cost components of the thesis requirement were broadly categorized as either indirect or direct. The indirect costs included the opportunity costs of students' and faculty advisors' time. The direct costs included the expenses of processing, cataloging, storing, and binding as well as thesis travel costs.

1. Average and Marginal Direct Costs

Focusing first on the direct costs, we can easily determine the average, and therefore marginal cost of these expenses. From Chapter 4 we know that direct costs totaled $326,469. Dividing this sum by the total number of theses produced yields an average/marginal direct cost of $480.10 ($326,469 ÷ 680) per thesis.

It should be noted that this figure includes the cost of thesis travel. Since not all theses required travel, this manner of including travel expenses in the calculation of average direct cost spreads the cost of travel over *all* theses produced in FY2000 as opposed to those specifically generating travel expense. This technique is used here based on the assumption (verified by the NPS comptroller in Reference 4) that thesis travel in FY2000 was representative of thesis travel in all years.

A final point on average direct cost associated with thesis production is warranted here. It is this author's opinion that the NPS personnel responsible for processing, binding, storing, and cataloging new theses each year are extremely competent and that the system of handling new theses is quite refined. These activities, therefore, are assumed to be conducted at maximum efficiency. In further discussions of marginal cost of thesis production this report, therefore, will not consider it possible to reduce average direct costs by improving the process.

2. Average and Marginal Indirect Costs

As shown in Chapter 4, the cost of U.S. students' time required to complete thesis work in FY2000 was $14,663,154. This was based on the assumption of 551 U.S. students each working 70.6 days on their theses. By dividing the $14,663,154 by the

number of students, we get an average cost per day for the entire student body (based on FY2000 demographics) of $26,611.89. By dividing this amount by the number of days assumed necessary to complete a thesis (70.6), we get an average cost per student, per day of thesis work required to complete one thesis. Based on the FY2000 mix of ranks and services of U.S. students, that figure was $376.94 ($26,611.89 ÷ 70.6) per student, per day spent at NPS while working on a thesis.

As discussed above, there is no fixed cost associated with students' time devoted to thesis work. Therefore, the $376.94 of average cost is also the amount of variable and marginal cost associated with students' time.

Chapter 4 showed that the total opportunity cost of faculty time spent advising students on thesis work in FY2000 was $4,797,635. In order to find the average cost, we divide this total cost by the total number of theses produced (680). Notice that average cost of faculty time, unlike students' time, must be based on the thesis production of all students, not just U.S. students. The average cost of thesis advising in FY2000 was $7,055.35 ($4,797,635 ÷ 680) per thesis. It is important to remember that each thesis requires two advisors. Therefore, the average cost of thesis advising can be considered $7,055.35 per two advisors, per thesis; or, $3,527.67 ($7,055.35 ÷ 2) per advisor, per thesis.

Now that all variable costs have been put into terms of those required to produce an individual thesis, we can derive a formula depicting the total cost of thesis production. In general terms, such a formula will be as follows:

TC = FC + VC Students' Time + (AT)VC Advisors' Time + (T)VC Processing

Where TC = Total Cost

FC = Fixed Cost

VC = Variable Cost

A = Number of Advisors per Thesis, and

T = Number of Theses Produced

The variable cost for students' time, as discussed above, is the number of U.S. students (S), multiplied by the number of days required to complete one thesis (D), multiplied by the cost per day. Since there are no fixed costs, the actual total cost function for thesis production becomes:

$$TC = f(S,D,A,T) = (S * D * 376.94) + (A * T * 3527.67) + (T * 480.10)$$

Where S = Number of U.S. Students Completing Theses

D = Number of Days Assumed Necessary to Complete One Thesis

A = Number of Advisors per Thesis, and

T= Total Number of Theses Produced (all students).

3. Partial Derivatives of the Thesis Cost Function

With this total cost function identified, we can now compute the partial derivatives with respect to each input factor. In this manner, we can see the effect on total cost of a unit change in each variable while holding all other variables constant. In this chapter, input factors will be allowed to vary without consideration for the policy ramifications of such variations (i.e., we can see the effect on total cost of requiring that only one less student to do a thesis—not a very likely policy decision). The intent here is

merely to isolate and determine the marginal effects of each input variable. The impacts on policy will be discussed in Chapter 6.

The partial derivative of the total cost function with respect to the number of U.S. students completing theses is: $\frac{\partial TC}{\partial S} = D376.94$.

The partial derivative of the total cost function with respect to the days required to complete a thesis is: $\frac{\partial TC}{\partial D} = S376.94$.

The partial derivative of the total cost function with respect to the number of advisors working on a thesis is: $\frac{\partial TC}{\partial A} = T3527.67$.

The partial derivative of the total cost function with respect to the total number of theses written is: $\frac{\partial TC}{\partial T} = A3527.67 + 480.10$.

Having identified these partial derivatives, one can now easily determine what effect marginal changes (or errors in assumptions) in input factors will have on the total cost of the thesis requirement. An interpretation of these partial derivatives, using the number of students as an example, would be as follows: For every one-unit increase (decrease) in U.S. students working on a thesis, the total cost can be expected to increase (decrease) by the number of days spent at NPS while working on the thesis (D) multiplied by $376.94, holding all other variables constant.

C. SENSITIVITY ANALYSIS OF THESIS BENEFITS

Sensitivity analysis of the thesis benefits is much more straightforward than that of the costs. In Chapter 3 it was determined that the present value of the indirect benefits of thesis research in FY2000 was around $8,328,767, but possibly as high as $18,375,342 depending on the quality and relevance of the theses. Just as in the previous section,

these values will be converted into average indirect benefits per thesis by dividing each value by the total number of theses produced in FY2000 (680). The average indirect economic benefit was calculated between $12,248.19 and $27,022.56 per thesis.

Recall from Chapter 3 that there was an unknown direct benefit (P) included in the total benefit calculation. The thesis benefit function, therefore, becomes:

$$TB = f(T,P) = T12248.19 + P$$

at the lower bound of economic benefit, and:

$$TB = f(T,P) = T27022.56 + P$$

at the upper bound where

T = Total Number of Theses Produced (all students), and

P = Productivity Increase of Graduates Due to Having Completed a Thesis.

With this total benefit function identified, we can now compute the partial derivatives with respect to each output factor.

The partial derivative of the total benefit function with respect to the number of theses written is: $\frac{\partial TB}{\partial T} = 12248.19$

at the lower bound of indirect benefit, and

$$\frac{\partial TB}{\partial T} = 27022.56$$

at the upper bound of indirect benefits.

The partial derivative of the total benefit function with respect to the productivity increase of graduates due to having completed a thesis is unknown.

D. CONCLUSION

The partial derivatives identified in this chapter are of little use in and of themselves. Their value will be apparent as alternative curricula programs and thesis processes are identified in the following chapter as areas for further research.

VI. CONCLUSIONS AND RECOMMENDATIONS

A. INTRODUCTION

This chapter summarizes the conclusions drawn from the empirical analysis of this thesis and provides recommendations. The chapter also proposes recommendations for further research into the costs and benefits of, as well as alternatives to, the thesis requirement.

B. CONCLUSIONS

In Chapter 3 it was determined that the annual indirect benefits of thesis research, in FY2000, was around $8,328,767, but possibly as high as $18,375,342. Chapter 3 also discussed, but did not monetize, the direct benefits of the thesis. Therefore, we can say that present value of the total benefit to the DoD due to the thesis requirement in FY2000 was as follows

$$TB = \$8,328,767 + P$$

Where TB is total benefit and P is the unknown direct benefit of the thesis in the educational process.

In Chapter 4 it was shown that the thesis requirement generated an annual total cost (TC) to the DoD in FY2000 of approximately $19,787,258. This total cost, while subject to sensitivity analysis, was less ambiguous than the total benefit.

Finally, the decision to either maintain the thesis requirement or abolish it depends on whether net economic benefits are positive. If total benefit exceeds total cost,

then the thesis requirement generates positive net economic benefits. The question, therefore, Is

$$TB - TC \geq 0 \ ?$$

Substituting our values for TB and TC yields the following expression at the lower bound of estimated indirect benefit:

$$(\$8,328,767 + P) - \$19,787,258 \geq 0$$

Finally, solving for P, the unknown direct benefit yields,

$$P \geq \$11,458,491$$

To use the upper bound for the value of indirect benefits, the calculations are as follows:

$$(\$18,375,342 + P) - \$19,787,258 \geq 0$$

In this case, solving for P, the unknown direct benefit yields,

$$P \geq \$1,411,916$$

Therefore, assuming the lower bound for direct benefits, the policy decision of whether or not to maintain the thesis requirement reduces to the question, "Is the present value of the direct benefits accruing to the DoD in the form of more productive officers for having completed a thesis (the shaded area in Figure 3.2) worth $11,458,491 or more per year?" That is, would the DoD be willing to pay up to this amount every year to maintain the thesis in the master's program due to its direct value in enhancing the overall graduate program? Assuming the upper bound of direct benefits, one can substitute $1,411,916 for $11,458,491 into the question.

Another way to look at it is to divide the unknown direct benefit by the number of U.S. students who completed a thesis in FY2000 (551). At the upper bound of direct benefit, this value, $20,796, represents the minimum average discounted increase in productivity per student (over the course of each individual career after graduation) necessary to break even. At the lower bound estimate of the direct value required to ensure positive net benefits of the thesis program the amount would be $2,562.

C. RECOMMENDATIONS

Based on the estimates for the costs and benefits, realizing that direct benefits are not measurable and that they represent the primary purpose of the thesis requirement, it is recommended that the DoD maintain its current policy of requiring a thesis as a condition for graduation from NPS.

D. AREAS FOR FURTHER RESEARCH

1. Determine the Direct Benefits of the Thesis Experience to the DoD

A shortcoming of this analysis is its lack of quantifiable data on the direct benefits accruing to the DoD in the form of an enhanced educational experience. A starting point toward quantifying these benefits might be a survey of NPS graduates seeking their opinions of (a) how much the thesis enhanced the educational process, and; (b) how much the thesis experience has enhanced their productivity in follow-on tours. Such analysis should take into account factors such as a graduate's follow-on assignments, the need for the skills developed by thesis work, and the length of time spent on active duty after leaving NPS.

Also, if it is determined that the thesis is a key element of a graduate education experience, the DoD should evaluate all programs where it sends its officer to receive master's degrees. Many service members attain master's degrees at civilian institutions on programs such as the Marine Corps' Advance Degree Program (ADP). While students typically pay their own tuition in these programs, the opportunity costs to the DoD are comparable to the NPS program. Further, many of these schools do not require a thesis. If the thesis is considered vital to graduate education, it should be studied whether or not the DoD should send students to schools that do not require a thesis.

2. Evaluate Alternatives to the Thesis

It is worth evaluating how other graduate degree programs are structured at some of the nation's best universities. As shown in Chapter 2, most of the top-rated universities do not require a thesis. If NPS abolishes its policy of requiring thesis work, there may be other curriculum alternatives to replace the thesis. Possible alternatives might include more classroom hours, a comprehensive final exam, or some form of group project.

It should be noted that many elite universities offer additional classroom hours in lieu of a thesis requirement. At NPS, however, students already spend more hours in classes than students at most civilian graduate schools. In fact, "the typical NPS student receives...768 hours of instruction per year. In contrast, civilian-sector graduate students typically receive 486 hours of instruction per year...." [Ref. 18: p. 62]

It must be remembered, however, that adding more hours to the NPS curricula will not eliminate opportunity costs in the form of students' time. The magnitude of

additional time spent at NPS on total cost can be determined from the partial derivatives calculated in Chapter 5.

3. Evaluate the Thesis Process

As shown in Chapter 4, the largest portion of costs associated with the thesis requirement is the opportunity cost of students' time. In fact, it was shown that, using the demographics of the graduates in FY2000, it costs the DoD $207,694 for each additional day of thesis work required by a year's cohort of students (or approximately $376.94 per day per student). If the time allotted, and taken, for thesis work can be reduced, the DoD might be able to avoid some of the opportunity cost. One way to reduce time spent on thesis work might be to make all theses joint projects between two or more students.

In a similar vein, the opportunity cost of faculty time for advising could easily be reduced by eliminating the requirement that two professors advise on each thesis. The ramifications and extent of the savings of such a policy would need to be studied in depth.

The effect of any changes on the thesis process can be predicted by using the partial derivatives shown in Chapter 5. It should be remembered that some changes, such as a reduction in the total number of theses completed, would impact both the economic costs and the benefits.

THIS PAGE INTENTIONALLY LEFT BLANK

APPENDIX A. MILITARY COMPOSITE STANDARD PAY AND REIMBURSEMENT RATES (FY2000) FOR OFFICERS

Department of the Army

Military Pay Grade	Average Basic Pay Allowance	Annual Rate Billable to Non-DoD Entities
O-10	$110,700	$165,250
O-9	$110,700	$170,175
O-8	$107,433	$156,900
O-7	$94,921	$144,175
O-6	$80,898	$133,900
O-5	$65,903	$111,650
O-4	$54,075	$94,025
O-3	$43,944	$77,900
O-2	$33,071	$58,925
O-1	$25,042	$45,050

Department of the Navy

Military Pay Grade	Average Basic Pay Allowance	Annual Rate Billable to Non-DoD Entities
O-10	$110,700	$166,250
O-9	$110,700	$172,625
O-8	$107,041	$165,050
O-7	$94,430	$149,350
O-6	$79,930	$136,875
O-5	$64,019	$115,450
O-4	$51,857	$98,775
O-3	$42,731	$86,050
O-2	$34,906	$66,925
O-1	$26,162	$53,175

Marine Corps

Military Pay Grade	Average Basic Pay Allowance	Annual Rate Billable to Non-DoD Entities
O-10	$110,700	$164,775
O-9	$110,700	$161,325
O-8	$107,023	$155,500
O-7	$94,454	$145,700
O-6	$81,293	$132,100
O-5	$65,845	$110,875
O-4	$56,613	$92,075
O-3	$43,530	$76,675
O-2	$34,988	$62,850
O-1	$26,061	$50,225

Department of the Air Force

Military Pay Grade	Average Basic Pay Allowance	Annual Rate Billable to Non-DoD Entities
O-10	$110,700	$171,000
O-9	$110,700	$168,075
O-8	$107,307	$163,375
O-7	$94,704	$146,800
O-6	$78,459	$134,650
O-5	$63,553	$115,250
O-4	$52,219	$99,625
O-3	$42,676	$82,025
O-2	$32,699	$60,650
O-1	$24,410	$46,275

APPENDIX B. NPS CURRICULA SUMMARY

Curriculum	Normal Length (Months)	Thesis Blocks
Aerospace Engineering		
Aeronautical Engineering	24	4
Aeronautical Engineering with Avionics	24	4
NPS/Test Pilot School	15*	0
Combat Systems Sciences & Technology		
Combat Systems Sciences & Technology	24	4
Applied Physics	18	3
Underwater Acoustics	18	4
Computer Programs		
Computer Science	24	4
Software Engineering	24	4
Modeling, Virtual Environments & Simulation	24	3 or 4
Electronics Systems Engineering		
Electronics Systems Engineering	24	4
Electronic Warfare		
Electronic Warfare Systems	24	4
Information Systems & Operations		
Information Systems & Operations	15	4
Information Systems Technology		
Information Systems Technology	24	3
Information Warfare		
Information Warfare	24	3
Joint Command, Control, Communications, Computers & Intelligence (C4I)		
Joint Command, Control, Communications, Computers & Intelligence (C4I) Systems	21	3
Intelligence Information Management	21	3
Meteorology and Oceanography		
Meteorology	15	4

METOC	24	5
Operational oceanography	24	5
Oceanography	24	5
National Security and Intelligence		
Middle East, Africa, South Asia	18	3
Far East, Southeast Asia Pacific	18	3
Western Hemisphere	18	3
Russia, Europe, Central Asia	18	3
Strategic Studies	18	3
Int'l Security & Civil-Military Relations	15	5
Regional Intelligence	18	3
Naval/Mechanical Engineering		
Naval/Mechanical Engineering	24	4
Reactors/Mechanical Engineering	18*	0
Operations Analysis		
Operations Analysis	21	3
Operational Logistics	21	3
Advanced Science (Applied Mathematics)	24	4
Space Systems		
Space Systems Operations (International)	24	4
Space Systems Operations	24	3
Space Systems Engineering	27	3
Special Operations		
Special Operations	18	3
Systems Engineering/Integration		
Systems Engineering/Integration	18	4
Systems Management		
Transportation Logistics Management	21	4
Transportation Management	21	4
Acquisition & Contract Management	18	3
Systems Acquisition Management	18-21**	3
Defense Systems Analysis	18	3
Defense Systems Management (International)	18	3
Systems Inventory Management	18	3
Resource Planning and Management for International Defense	18	3
Material Logistics Support Management	18	3

Contract Management	27***	-
Program Management	27***	-
Financial Management	18	3
Manpower Systems Analysis	21	4
Leadership Education and Development	12	2
Shore Installation Management	18	3
Undersea Warfare		
Undersea Warfare	24	4
Undersea Warfare (International)	24	4

* denotes a non-thesis program
** program is 18 months for U.S. Army students; 21 months for all others
*** civilian programs only

THIS PAGE INTENTIONALLY LEFT BLANK

LIST OF REFERENCES

1. Boardman, Anthony E., David H. Greenberg, Aidan R. Vining, and David L. Weimer. Cost-Benefit Analysis: Concepts and Practice. Upper Saddle River, NJ: Prentice Hall, 1996.

2. Bowman, William R. "Are Service Academies Worth the Price? New Evidence From Navy Warfare Communities," Unpublished Report, June 1994.

3. Bowman, William R., and Stephen L. Mehay. "Graduate Education and Employee Performance: Evidence from Military Personnel." Economics of Education Review, 1999.

4. Cartwright, Chuck (NPS Comptroller). Email correspondence with author dated 31 Jan 2001.

5. Christian, Elaine (NPS Thesis Processor). Email correspondence with author dated 20 Feb 2001.

6. Christian, Elaine (NPS Thesis Processor). Personal interview with author on 29 Nov 2000.

7. Conrad, Clifton F., Jennifer Grant Haworth, and Susan Bolyard Millar. A Silent Success: Master's Education in the United States. Baltimore, MD: The Johns Hopkins University Press, 1993.

8. Cylke, Steve (BUPERS, N-13). Email correspondence with author dated 20 Dec 2000.

9. Donald, Janet G., and Arthur M. Sullivan, eds. Using Research to Improve Teaching. San Francisco: Jossey-Bass, Inc., 1985.

10. Ehrenberg, Ronald G., and Robert S. Smith. Modern Labor Economics: Theory and Public Policy. Reading, MA: Addison-Wesley, 2000.

11. Gates, William R., Xavier K. Maruyama, John P. Powers, Richard E. Rosenthal, and Alfred W. M. Cooper. "A Bottom-Up Assessment of Navy Flagship Schools: The NPS Faculty Critique of CNA's Report." Naval Postgraduate School, Montery, CA, November 1998.

12. Joyce, Judy (NPS Registrar's Office). Email correspondence with author dated 12 Jan 2001.

13. Koefod, Paul E., The Writing Requirements for Graduate Degrees. Englewood Cliffs, NJ: Prentice Hall, Inc., 1964.

14. Kuska, Danielle (NPS Research Office). Email correspondence with author dated 23 Jan 2001.

15. Lathroum, John A., *A Comparative Analysis of Graduate Management Education*, Master's Thesis, Naval Postgraduate School, Monterey, CA, March 1998.

16. Laurence, Janice (BUPERS, N-13). Phone conversation and email correspondence with author dated 20 Feb 2001.

17. Mankiw, N. Gregory. Principles of Economics. Orlando, FL: The Dryden Press, 1998.

18. Mauz, Admiral Henry H., and William R. Gates. "The Naval Postgraduate School: It's About Value." U.S. Naval Institute Proceedings, August 2000, 61.

19. *Naval Postgraduate School Catalogue*, Academic Year 2000, Naval Postgraduate School, Monterey, CA, 2000.

20. *Naval Postgraduate School Self-Study: Presented to the Western Association of Schools and Colleges for Reaffirmation of Accrediation (sic)*, Naval Postgraduate School, Monterey, CA, 15 Jan 1990.

21. Naval Postgraduate School Thesis on the Internet Committee, Memo dated 26 Oct 1998.

22. Panel on Engineering Graduate Education and Research. Engineering Graduate Education and Research. Washington, D.C.: National Academy Press, 1985.

23. *U.S. News and World Report*, "2000 Graduate School Rankings", [http://www.usnews.com/usnews/edu/beyond/gradrand/gbengsp1.htm], accessed 13 Nov 2000.

24. Williams, Layne (NPS Librarian). Email correspondence with author dated 2 Feb 2001.

25. Williams, Layne (NPS Librarian). Email correspondence with author dated 6 Feb 2001.

26. Zander, Laura (NPS Strategic Planning and Research Office). Email correspondence with author dated 8 Feb 2001.

INITIAL DISTRIBUTION LIST

No. Copies

1. Defense Technical Information Center 2
   8725 John J. Kingman Rd., Ste 0944
   Ft. Belvoir, VA 22060-6218

2. Dudley Knox Library 2
   Naval Postgraduate School
   411 Dyer Road
   Monterey, CA 93943

3. Director, Training and Education 1
   MCCDC Code 46
   1019 Elliot Road
   Quantico, VA 22134-5027

4. Director, Marine Corps Research Center 2
   MCCDC Code C40RC
   2040 Broadway Street
   Quantico, VA 22134-5107

5. Marine Corps Representative 1
   Naval Postgraduate School
   Code 037, Bldg. 330, Ingersoll Hall, Room 116
   555 Dyer Road
   Monterey, CA 93940

6. Marine Corps Tactical Systems Support Activity 1
   Technical Advisory Branch
   Attn: Major J.C. Cummiskey
   Box 555171
   Camp Pendleton, CA 92055-5080

7. Prof. Stephen Mehay 2
   Graduate School of Business and Public Policy
   Naval Postgraduate School
   Monterey, CA 93943-5000

8. Prof. Julie Filizetti 1
   Graduate School of Business and Public Policy
   Naval Postgraduate School
   Monterey, CA 93943-5000

9. Maxine Reneker 1
   Dudley Knox Library
   Naval Postgraduate School
   Monterey, CA 93943-5000

10. Richard S. Elster 1
    Provost and Dean of Academics
    Naval Postgraduate School
    Monterey, CA 93943-5000

11. David W. Netzer 1
    Dean of Research
    Naval Postgraduate School
    Monterey, CA 93943-5000

12. Major Michael R. Strobl, USMC 2
    15 Gray Birch Lane
    Stafford, VA 22554